

Short Communication

Threshold Sugar Concentrations in Snowden Potatoes During Storage

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ABSTRACT

The suitability of potatoes for processing into potato chips is dependent on chip color, and internal and external defects. Concentrations of reducing sugars, and more specifically glucose, have been used as a quantitative indicator of acceptability of potato for chipping. The research reported here investigated the correlation between sugar concentrations and chip color, and the variability of sugar concentrations between samples and sample locations. Three potato storage research bins, each with an independent air handling and control system, were located inside of commercial potato storage bins. Snowden potatoes were harvested in the fall of 1992 and stored at different temperatures in the bins through late March, 1993. The potatoes were sampled bi-weekly during the storage period, and the samples were analyzed for sugar concentrations (sucrose and glucose) using a YSI model 2700 sugar analyzer.¹ The results indicated that a Snowden potato sample with a glucose concentration less than 0.0075%² (fresh weight basis) will have a 90% probability of having an acceptable Snack Food Association color score of 1.5 or lower. Lower numbers indicate whiter chips which are generally preferred by

chip producers. Similarly, a sample with a glucose concentration of 0.01% will have a 90% probability of having a color of 2 or lower. Based on tubers sampled from four heights within the storage bins, samples from the top of a potato bin will provide a representative sample as long as recommended storage procedures are followed, and potato pulp temperatures are similar throughout the storage.

INTRODUCTION

The intended market for the stored potatoes will affect the choice of storage conditions. The principal markets for potatoes in Michigan are seed, table stock, and chip processing. Storage conditions are most restrictive for processing potatoes where a low and uniform content of reducing sugars is required (Burton *et al.*, 1992). Prolonged exposure to low storage temperatures and stress (e.g. handling, rapid temperature change, oxygen depletion) can cause starch conversion to sugars and will cause dark colored processed products, a result of a Maillard reaction between the reducing sugars and amino acids in the potatoes (Talbert *et al.*, 1987).

The suitability of potatoes for processing into potato chips is dependent on chip color and internal and external defects. Though chip color is the true test of potato marketability, chip color is more difficult to quantify than sugar concentration. Concentrations of reducing sugars, and more specifically glucose, have been used as a quantitative indicator of acceptability of potatoes for chipping. Changes in sugar concentrations will occur before detectable changes in chip color. Research (Mazza *et al.*, 1983, Leszkowiat *et al.*, 1990) has demonstrated that reducing sugars, though not the only factor, are an important factor in the darkening of chips. Sowokinos and Preston (1988) developed procedures for

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ADDITIONAL KEY WORDS: Chipping potatoes, glucose, sucrose, reducing sugars, Maillard reaction.

¹Trade names are used solely to provide specific information. Mention of a trade name does not constitute a warranty of the product by the authors or by Michigan State University or an endorsement of the product to the exclusion of other products not mentioned.

²Glucose concentration limits are derived from Figure 3. The YSI model 2700 sugar analyzer can provide data accurate to only 3 significant digits.

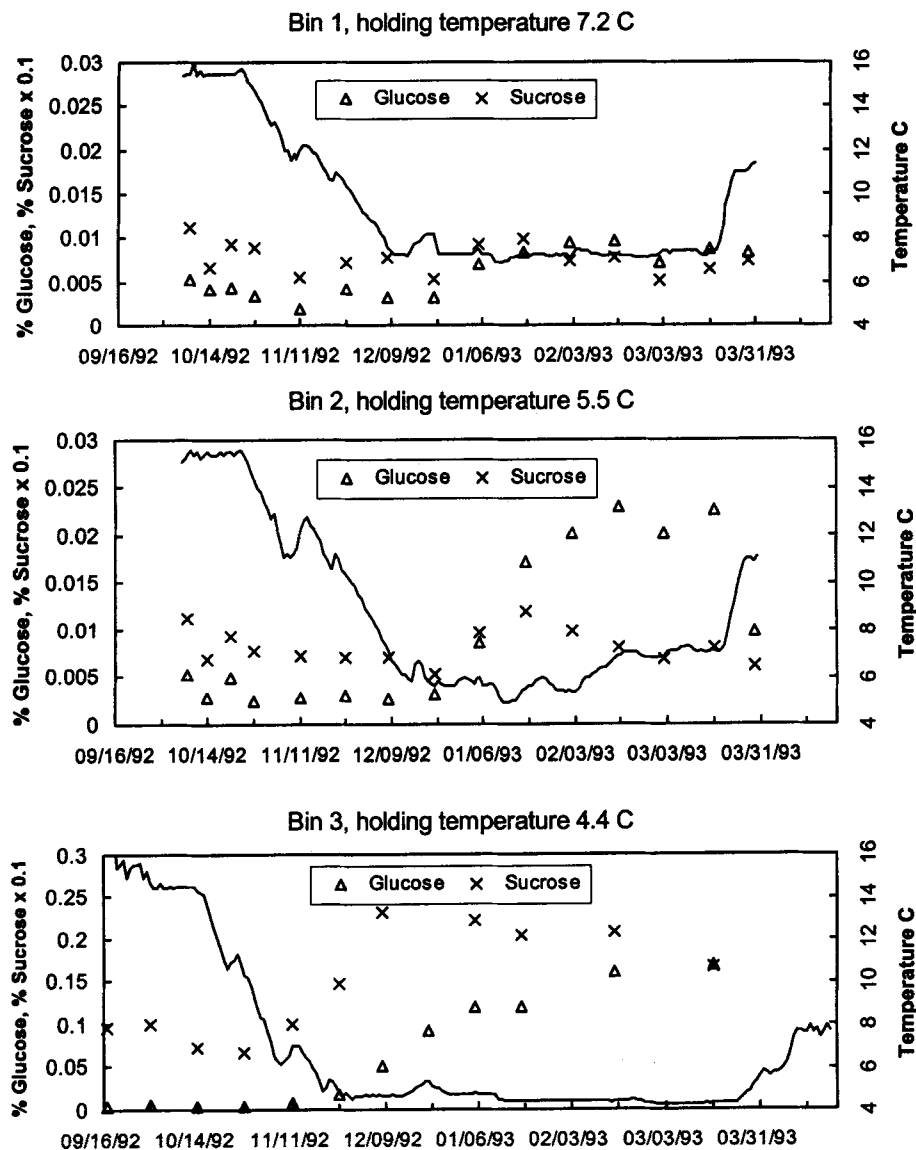


FIGURE 2.

Graphical presentation of the temperature and sugar concentrations data for samples from the potato storage research bins during the 1992/1993 storage season. Data illustrates the changes in sugar (sucrose and glucose) concentrations as affected by storage temperature and temperature variability during 6-months of storage. Note change in scale of glucose and sucrose concentrations for bin 3.

All the sample results were resorted by glucose concentration in ascending order, divided into intervals, and the percentage of acceptable samples in each interval calculated. The interval width was small (0.001% glucose) for low sugar concentrations (0.004-0.005% glucose), with larger intervals used at higher sugar concentrations so that each interval had at least five samples.

A Snack Food Association's rating of 1 or 1.5 is required to assure acceptability of potatoes for chipping; a rating of

2 is considered marginal, being acceptable under some market conditions. Two acceptable conditions were defined: samples having a chip color score of 1.5 or less, and samples having a chip color score of 2.0 or less. The percent of acceptable samples per interval versus glucose concentration for each acceptable condition are plotted in Figure 3 along with approximate curves fit to the data.

Based on the data presented in Figure 3, a potato sample with a glucose concentration of 0.0075%² (fresh weight

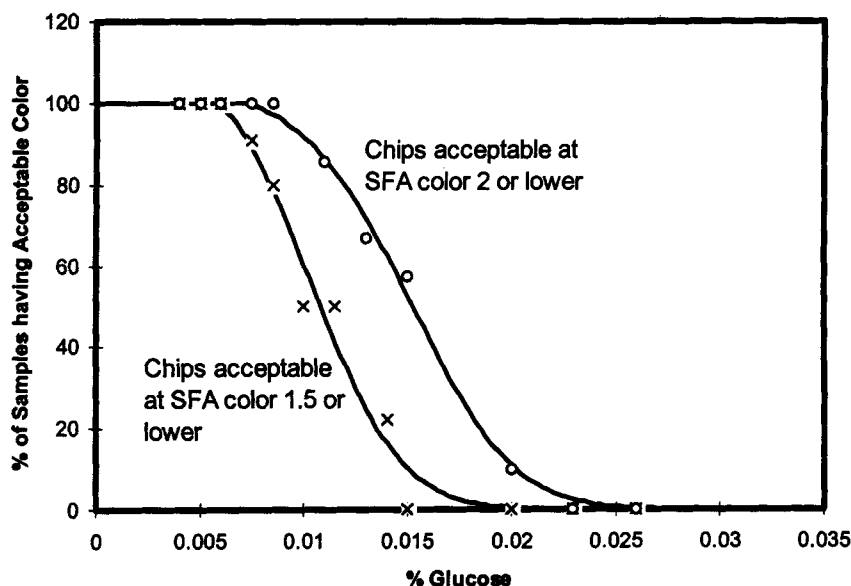


FIGURE 3.

The effect of tuber glucose concentration on the probability of potato chip samples having acceptable chip color ratings. Data points are percent of samples acceptable in the surrounding interval; lines are best-fit to the data.

basis) will have a 90% probability of having a color of 1.5 or lower (Figure 3). Similarly, a sample with a glucose concentration of 0.01% will have a 90% probability of having a color of 2 or lower.

Variability in Sample Sugar Concentrations by Location in Storage Bin—The sugar concentrations for the samples taken at the four levels in each of the three potato storage research bins (0.6, 1.7, 3.0 and 4.3 (top) meters above the floor) were compared. A statistical paired t-test was performed to test the hypothesis that the difference between paired means of sample locations was zero ($p=0.05$ level of significance). The sample results compared in this test were limited to those samples with chip colors that were acceptable or marginally acceptable (chip color not greater than 2.5 or glucose concentrations below 0.02%).

There were no statistical differences, at the $p=0.05$ level of significance, in the means of glucose concentrations between samples from any of the four levels for all three bins. There were no statistical differences, at the $p=0.05$ level of significance, in the means of sucrose concentrations between samples taken at 0.6 and 3.0 m, or between samples taken at 1.7 and 4.3 m. There was statistical evidence that the means of sucrose concentrations for samples taken at 1.7 and 4.3 m were not equal to the sucrose concentrations for samples taken at 0.6 and 3.0 m. The differences in the

sucrose concentrations can be attributed to a procedural error in the sugar analysis techniques, described below.

The order in which the potato samples from the four locations in the bins were juiced was kept the same. Because the cleaning and changing of the filter was a time consuming process, the filter was changed every two samples. Therefore juice from samples taken at heights of 1.7 and 4.3 m would be rinsed through pulp from samples taken from heights of 0.6 and 3.0 m, respectively. An analysis of the data indicated that the differences in sucrose concentrations for tubers at 1.7 and 4.3 m were nearly the same as the differences noted for tubers at 0.6 and 1.7 m. Without the procedural error, the sucrose concentrations for the four sampling locations would all be equivalent.

Conclusions—A procedure has been illustrated that can be used to establish a correlation between the sugar concentrations and the color of the chips produced from tuber samples. Our results indicated that a Snowden potato sample with a glucose concentration of 0.0075% (fresh weight basis) will have a 90% probability of having an acceptable Snack Food Association color score of 1.5 or lower (lower number indicates whiter chips). Similarly, a sample with a glucose concentration of 0.01% will have a 90% probability of having a color of 2 or lower. Based on tubers sampled from four heights within the potato storage research bins, samples

($2n=2x=24$) and *Solanum sucrense* Hawkes ($2n=4x=48$). RAPD banded-plant frequencies for a total of 85 marker loci within each of 15 populations were assessed using 29 plants per population. For both species, about 10% of within-population bands were vulnerable (frequency <40%), considering just the particular population in question. However, about half of these were fixed (therefore invulnerable) in at least one other population. The highest within-population frequency for bands not fixed in any population was, with one exception, always >40%. So, while many RAPD alleles are vulnerable within populations, these are nearly always fixed or nearly fixed (invulnerable) in another population. This indicates that the most effective strategy for conserving all alleles is to apportion available resources among many separate Mendelian populations rather than to select a representative few for rigorous attention.

Berlanger, Ingrid E., M.L. Powelson, and K.B. Johnson. *Verticillium Wilt Suppression With a Broccoli Green Manure*.

A field study was conducted in 1997 and 1998 to determine the effect of a broccoli green manure on *Verticillium* wilt of potato in the Willamette Valley of Oregon. Broccoli was grown in field plots artificially infested with *Verticillium dahliae*. Following the incorporation of the broccoli green manure (4.63 kg/m²) to a depth of 15 cm in August, the soil organic matter content was unaffected; soil populations of *V. dahliae*, however, were significantly less ($p \leq 0.05$) in broccoli amended soil than in fallowed soil in both 1997 and 1998. Disease severity in cultivar Russet Norkotah, measured as AUSPC (area under the senescence progress curve), was reduced by 40% in broccoli amended compared to fallowed soil in 1998 ($p \leq 0.05$). Mean total tuber yield was 9.6% higher in broccoli amended plots than in fallowed plots, however, the difference was not significant.

Small volumes (0.5 L) of a field soil artificially infested with *V. dahliae* were amended with a broccoli green manure at rates of 0, 0.28, 0.56, 1.12, or 2.24 kg/L soil and incubated at 25 C for 19 days. The log transformed mean soil populations of *V. dahliae* were negatively correlated ($r = -0.73$) with the amount of biomass incorporated.

Soils naturally infested with *V. dahliae* were collected from Idaho and Washington potato fields, amended with a broccoli green manure (1.12 kg/L soil), and incubated at 25 C for 17 days. Soil populations of *V. dahliae* in greenhouse experiments were 50 to 80% less in broccoli amended soils compared to non-amended soils in 3 of 4 trials. This effect occurred in both a Delco loam and a Quincy fine sandy loam soil.

Bisognin, D.A., D.S. Douches, K. Jastzrebski, and W. Kirk. *Progeny Evaluation of Potato Late Blight Resistant Clones*.

Potato breeding has refocused on late blight (LB) - *Phytophthora infestans* - resistant breeding, because of the increased aggressiveness and frequency of new races. Since most of the LB resistant sources are late in maturity and poor in tuber quality, it is very important to know how LB resistance sources combine with susceptible adapted germplasm. The objectives of this study were 1) to evaluate the value of different LB resistant clones associated with tuber quality (chip-processing or tablestock), and 2) to develop a selection procedure capable of identifying superior individuals in early stages of selection for varietal development. We made crosses among 8 clones (B0718-3, Bertita, Bzura, Greta, Libertas, Stobrawa, Tollocan and Zarevo) with reported LB resistance and a sample of susceptible ones to produce 95 families (4,750 seedlings). In 1997, a phenotypic selection in single hill resulted in 408 (8.6%) clones that were evaluated for chip-quality, tuber appearance and specific gravity. A random sample of tubers from each 8-hill plot were used to evaluate the clones again in 1998. Also, the clones were evaluated for their LB reaction in greenhouse and in the field trials using LB isolates of the US-8 genotype. Based on either the percentage of selected clones or mean progeny performance ($P < 0.05$) the best parents for tuber quality were Zarevo, Tollocan, and Greta. Overall, 12% and 21% of the clones based on single and 8-hill plot data, respectively, were considered potential clones for chip-processing and over 90% of the clones for tablestock. Correlation analysis between single and 8-hill data was high for tuber appearance ($r = 0.77$) and specific gravity ($r = 0.92$) indicating that selection could be done in both stages. The LB parents that resulted in highest percentage of selected clones were Tollocan, Zarevo, B0718-3, and Greta. Combining LB resistance with tuber quality, 6% were considered potential clones for chip-processing and 28% for tablestock. In conclusion, the LB resistant parents differ in their ability to transmit tuber quality characteristics and LB resistance that can be combined in the offspring and superior clones for tuber appearance and specific gravity can be identified in single hill plots.

Bohl, William H. and Stephen L. Love. *Effect of Planting Depth on Yield and Agronomic Characteristics of Three Potato Varieties*.

Potato seed pieces were planted 8, 15, or 23 cm deep measured from the top of the hill to assess planting depth effects on yield and agronomic characteristics of three potato

varieties. Russet Burbank and Frontier Russet were planted in field studies 1995 through 1997 with Shepody being included in 1996 and 1997. Five single-cut seed pieces of each variety were hand-planted with cut side down in each of five replications. Seed pieces weighed 57-71 gm.

The number of days to reach 100 percent emergence averaged over years was significantly longer for each increase in planting depth for all varieties tested.

Planting at 23 cm compared with planting at 8 or 15 cm significantly reduced total yield of Russet Burbank and Frontier Russet, but total yield was not affected in Shepody. U.S. No. Russet Burbank yield was not affected by planting depth. Planting Frontier Russet 23 cm significantly reduced U.S. No. 1 yield compared with 8 or 15 cm. Shepody U.S. No. 1 yield was significantly decreased when planted 8 cm deep compared with 15 cm.

Planting Russet Burbank and Frontier Russet at 23 cm compared with 8 or 15 cm significantly increased the distance to the uppermost tuber. Planting Shepody at 15 or 23 cm compared with 8 cm significantly increased distance to the uppermost tuber. Each increase in planting depth significantly increased the distance to the lowermost tuber in all varieties.

The 23-cm planting depth did not significantly decrease green tuber yield, measured in 1996 and 1997, compared with 15 cm in these three varieties. Planting at 8 cm significantly increased green tuber yield in Frontier Russet and Shepody compared with 15 or 23 cm.

Boluarte, Tatiana and Richard E. Veilleux. *Molecular Markers Linked to Anther Culture Response and Leptine Content in Three Backcross Families Derived From Solanum phureja and S. chacoense.*

BARD 1-3, a clone of *S. phureja* and 80-1, a clone of *S. chacoense* shows high and low anther culture response (ACR), respectively. The same clones have 0 and high leptine content (LC) in their foliage, respectively. An F_1 hybrid (CP2) was intermediate for both traits, but self-incompatible. Two backcross (BC) families: PBCp (1-3 x CP2 — 78 individuals) and CBC (CP2 x 80-1 — 54 individuals) were phenotypically characterized for ACR. High and low selections were used for bulk segregant analysis (BSA). PBCp and its reciprocal PBCc (CP2 x 1-3) were screened for LC. High and low leptine genotypes were again selected for BSA. A total of 160 RAPD primers was screened in these bulks. A band amplified by OPQ10 primer was found to be linked in repulsion to ACR in PBCp. Another band amplified by OPW14

primer was found to be linked in coupling to ACR. Two primers OPQ2 and OPW10 amplified bands linked in coupling to LC in both the PBCp and PBCc families. Analysis of individual genotypes verified linkage of the markers to the traits.

Bradeen, James M., S. Kristine Næss, Susan M. Wielgus, Geraldine T. Haberlach, and John P. Helgeson. *Late Blight Resistance From Solanum bulbocastanum: Towards Fine Mapping and BAC Clone Isolation.*

Late blight remains a disease of major importance to potato production worldwide. Although no U.S. cultivars are adequately resistant, the wild diploid *Solanum bulbocastanum* is highly resistant even under extreme disease pressures. However, *S. bulbocastanum* is sexually incompatible with potato. Late blight resistant hexaploid potato + *S. bulbocastanum* somatic hybrids, backcrosses of somatic hybrids to potato, and a *S. bulbocastanum* diploid population are the subjects of continued mapping efforts using RFLPs, RAPDs, and AFLPs. Markers linked to late blight resistance were used to identify BAC clones from a library constructed from *S. bulbocastanum*. Further characterization of these clones is ongoing. Among our goals are contig development (*i.e.* alignment of overlapping BAC clones) for regions near late blight resistance and development of markers better adapted to large scale breeding efforts.

Brown, C.R., H. Mojtahedi, and G.S. Santo. *Genetic Analysis of Resistance to Races 1 and 2 of Meloidogyne chitwoodi Derived From the Mexican Wild Species Solanum Hougasii.*

An accession of *Solanum hougasii*, a wild tuber-bearing potato species native to Mexico was found to be resistant to races 1 and 2 of *Meloidogyne chitwoodi*. A resistant selection was selfed and the progeny possessed the same combined resistance uniformly. A selected resistant seedling from the selfed progeny was crossed to cultivated tetraploid potato to form a F_1 hybrid, and this was backcrossed to cultivated tetraploid potato to form a BC_1 population in which resistance to the two races segregated. Progeny of the BC_1 were tested in inoculation experiments with four replicates for each progeny genotype for each race of nematode. Resistance was evaluated on the basis of extracted egg counts from the entire root system of pot grown plants. Considering resistance to each race separately, for race 1, non-host status was exhibited by approximately half of the BC_1 . About one-third of the progeny showed nonhost status to race 2. Egg production among progeny which showed non-host

($2n=2x=48$) and 53 of *S. jamesii* ($2n=2x=24$). These species represent two of the most predominant breeding systems among *Solanum* species. RAPD markers were used to assess genetic variation through: (1) estimation of genetic differences and (2) estimation of genetic diversity. Results from 2,282 pairwise comparisons suggest that patterns of genetic differentiation are not explained by differences in eco-geographical variables. Remarkably, physical separation, a parameter very often used for collecting germplasm, did not predict genetic differentiation very well. The assessment of genetic diversity revealed that eco-geographical variables significantly predicted genetic diversity in *S. fendleri* populations. In contrast, genetic diversity had no significant association with eco-geographic components for the diploid species *S. jamesii*. This study reveals how genetic variation relates to geographical and environmental variables at sites of origin. Such information could help to enhance efficiency in collecting strategies.

Dong, Fenggao, Junqi Song, and Jiming Jiang. *Development of Chromosome-Specific Cytogenetic DNA Markers in Potatoes*.

Potato chromosomes are small and similar in size, making it impractical to identify the 12 different chromosomes by conventional somatic chromosome karyotyping, pachytene chromosome analysis and chromosome banding. A bacterial artificial chromosome (BAC) library was constructed from a diploid species *Solanum bulbocastanum*. DNA of 24,576 clones from this library were placed on 16 nylon filters and hybridized with potato DNA markers with known chromosomal locations based on restriction fragment length polymorphism (RFLP) mapping. BAC clones with positive hybridizations to the RFLP probes were selected and their DNA were hybridized onto potato chromosomes by fluorescence *in situ* hybridization (FISH). Such BAC clones generated distinctive and consistent FISH signals on both somatic metaphase chromosomes and meiotic pachytene chromosomes, which can serve as convenient and reliable cytogenetic markers for chromosome identification in potatoes. Cytological mapping of marker-tagged BAC clones can also integrate the cytogenetic chromosome numbering system with the one in genetic mapping. So far, 12 such markers have been isolated and tested, with one for each potato chromosome.

Englehart, Kathryn M. and Michael E. Vayda. *A Multiplex PCR System For Simultaneous Detection of Three Potato Viruses*.

A multiplex PCR assay for three potato viruses was

developed to augment ELISA screening of nuclear seed. Assays for Potato Virus X (PVX), Potato Virus Y (PVY) and Potato Leaf Roll Virus (PLRV) were developed independently and then optimized for simultaneous use in a single reaction. Efficacy of this technique was first assessed using samples known to contain, or be free of, the target viruses. In order to test the sensitivity and reliability of this assay, we applied the multiplex approach to screen potato leaf samples taken early and in the middle of the 1998 field season, and tubers from the same plants were tested upon harvest. This work was conducted at the Aroostook Farm in Presque Isle, ME. All materials tested by multiplex PCR assay were also screened by standard ELISA assay using Agdia kits. Our results to date indicate that the PCR multiplex assay can reliably and effectively detect viruses in singly- or multiple-infected plant tissues early in the field season.

Errampalli, Deena, Walter Arsenault, J. Brian Sanderson, and Tony Sturz. *Response of Four Different Potato Cultivars to Black Scurf of Potatoes*.

Rhizoctonia solani, the causal agent of black scurf of potato is found wherever potatoes are grown. This pathogen attacks potato at more than one stage in potato development and black scurf usually results in a decline in tuber quality. A field experiment was conducted to demonstrate the relationship between stem canker and black scurf stages, and yield in four potato cultivars, Kennebec, Shepody, Superior and Russet Burbank. Significantly higher disease incidence was observed on the *R. solani* inoculated treatments (18%) than non-inoculated treatments (10%). Relationships between black scurf, and total and marketable yields were observed. Black scurf disease progression in storage was assessed by comparing the disease incidence at harvest and after three months in storage. Significantly higher disease incidence was seen on tubers after storage (27%) than at harvest (14%). The effect of seed piece treatments on *R. solani* and yield will also be discussed.

Estrada, Nelson, R. Pineda, A. Rodriguez, and Sonia Tinjaca. *Crossability Between Solanum Stoloniferum and Solanum Palustre, Two Wild Potato Species*.

Solanum stoloniferum Schltdl, $2n=4x=48$, was crossed to *Solanum palustre* Schltdl, $2n=2x=24$ obtaining valuable and productive F1 hybrids. The first crosses were made on 1984 in Andean environmental conditions at 2600 m.o.s.l., near Bogota. A few of the hybrids appeared as tetraploids, being more tuber productive and showing acceptable cooking quality.

In fact, two of them have been released as commercial varieties: JASPE in Bolivia (clone CCC84-75-16) and MORITA (clone CCC 84-630-1). The parents of both clones were sto PI.160225 and pls PI 218228.

More recently 10 additional cross combinations have been made utilizing 5 different sto and two different pls PI accessions, getting about 700 seeds and some hybrids showing fairly good tuber types (3-4 cm).

S. stoloniferum is considered to be an allopolyploid species and its genomic differentiation and low homeologous pairing has been often postulated to explain its cytological and crossability results.

The purpose of these crosses was to get genetic materials more resistant to some virus diseases and to late blight.

Estrada, Nelson and Sonia Tinjaca. *Crossability Between Solanum Palustre and Solanum Etuberosum, Two Non Tuber Bearing Potato Species.*

Solanum palustre Schltdl (2n-2x=24) previously named *S. brevidens* was crossed successfully to *Solanum etuberosum* Phil, obtaining viable seeds and thrifty seedlings under the Andean conditions of Colombia and Bolivia (3000 m.o.s.l.).

On 1998, were planted 28 seeds obtaining after germination 17 seedlings which at maturity were able to produce from 2 to six small tubers (5 to 8 mm), but no flowers.

These clones were planted in February 1999 supplying them with extra daily light hours trying to induce flowering and to make possible crosses to diploid cultivated clones of the *Solanum phureja* species.

Both pls and etb species have genetic potential to transfer onto cultivated potatoes resistance to important virus diseases. *S. palustre*, in addition, has been reported as resistant to some bacterial diseases, as well as to late blight (field resistance) and to light frosts.

Ewing, Elmer E., Ivan Simko, Christine D. Smart, Merideth W. Bonierbale, Eduardo S.G. Mizubuti, Gregory D. May, and William E. Fry. *An R-Gene From Solanum berthaultii For Resistance to Phytophthora infestans Maps to Chromosome 10.*

A backcross population [(*Solanum tuberosum* x *S. berthaultii*) x *S. tuberosum* segregated for resistance to *Phytophthora infestans*, indicating the presence of an *R*-gene. The *R*-gene segregated from the *S. berthaultii* parent and mapped 4.8 cM from the RFLP marker *TG63* on chromosome 10. Other resistance genes have been reported in this region, including *Ph-2*, an *R*-gene from tomato. The tester clone was an isolate of the US-8 clonal lineage of *P. infestans*.

This isolate is compatible to *R*-genes 1, 2, 3, 4, 5, 7, and 10 and incompatible with *R*-genes 6, 8, 9, and 11. It is incompatible with *Ph-1* and *Ph-2* from tomato. Genotypes incompatible to US-8 were also incompatible when inoculated with an isolate of US-7 (compatible to *Ph-1* and *Ph-2*). From comparison with the location of the five other *R*-genes that have been mapped, the *R*-gene from *S. berthaultii* was not *R-1*, *R-2*, *R-3*, *R-6*, or *R-7*. Based upon compatibility, it does not appear to be *R-4*, *R-5*, *R-10*, *Ph-1*, or *Ph-2*.

Glass, Jenny Rebecca, K.B. Johnson, and M.L. Powelson. *Barriers to Potato Tuber Infection by Phytophthora infestans.*

An understanding of how *P. infestans* inoculum travels from potato foliage to infect developing tubers is crucial to the development of late blight management strategies. Our studies investigated if physical barriers, plastic mulches or deeper soil layers, could protect tubers from disease.

In the plastic mulching trial, Red la Soda tubers were planted in a randomized block with factorial treatments of stem and hill barriers. A PVC pipe surrounding the plant stem separated the stem area from the rest of the hill and the plots were mulched with black plastic and/or spray foam to prevent water containing spores from penetrating into these areas. Using foam to block movement of water down the stem had little effect on the percentage of diseased tubers ($P = 0.1697$) while plastic along the hill significantly reduced ($P = 0.0001$) the percentage of infection. On average, the percentage of infected tubers in the plots covered with black plastic was $31.8\% \pm 3.6\%$ as compared to $56.1\% \pm 3.6\%$ in plots without the black plastic mulch covering the hill.

In the hilling regime trial, three potato cultivars, Russet Burbank, Red la Soda and Shepody, were planted in a split-plot design with three hilling treatments. The low, medium and high hilling regimes, established by running a hilling machine over plots 0, 1 or 2 times, had cross-sectional areas of 263.2 ± 22.7 , 494.0 ± 18.9 , 662.1 ± 32.9 cm², respectively. Both hill ($P = 0.0005$) and cultivar ($P = 0.0001$) were shown to have an effect on the percentage of diseased tubers. On average, Red la Soda had $47\% \pm 3\%$ of the tubers infected, Shepody $39\% \pm 3\%$ and Russet Burbank $15\% \pm 3\%$. The low hill regime resulted in $40.3\% \pm 2.6\%$ diseased tubers as compared to the middle ($30.1\% \pm 2.6\%$) and high hills ($31.0\% \pm 2.6\%$).

Although tuber infestation appears difficult to suppress in a favorable environment, this research may provide direction for the development of management strategies that target this important stage of disease.

Goth, R.W. and E.W. Goins. *The Schultz Potato Virus Collection*.

The Schultz Potato Virus Collection, containing 17 distinct pathogens, some of which occur as strains, are maintained on Aroostook Farm, Presque Isle, Maine, and at Beltsville, Maryland. The collection, initiated in 1916, is maintained in cages to prevent contamination and insure against loss of the original virus. The collection was maintained by E.S. Schultz until his retirement in 1954, R.E. Webb 1954-1960, W.B. Raymer, 1960-1967, and R.W. Goth 1968-date. Each virus culture is maintained in tuber progeny and plants. Two seedlings, one designated S 41956 (immune to PVX) and another of cv Green Mountain (virus X-free) are used to maintain the viruses without PVX. Since the discovery of Potato virus S, in 1951, some entries are maintained in the cv Saco, which is immune to viruses PVA, PVS, and PVX. Each potato variety or seedling containing a virus culture is grown under 2 separate cages in the field. Four plants are grown in each cage. Since 1989 ELISA and nucleic acid tests for PSTVd have been used to test all plants for PVA, PVM, PVS, PVX, PVY, PLRV, and PSTV. Tubers harvested from these cages are used for replanting and distribution to other investigators. In addition to serving as Type cultures, material from this collection has been used to study physical properties, strain variations, serological properties, virus-vector relationships, genetics and the development of disease-resistant cultivars.

Halseth, Donald E., W.L. Hymes, and Randy L. MacLaury. *Benefits of Pre-Warming and Pre-Cutting Seed of Long Dormancy Clones*.

Many new clones from the Cornell potato breeding program have relatively long tuber dormancy. NY101, Andover, Pike, NY103 and Allegany have tuber dormancies of 2.2, 6.1, 6.3, 8.5 and 10.8 weeks longer than Atlantic, respectively. As seed of all of our breeding and extension yield trials are warmed and cut one to two months in advance of planting, tuber dormancy is not considered a problem. However, as many NYS growers cut and plant within a day or two, tuber dormancy may have an impact on stand and yield. Several seed handling experiments have been conducted to assess the level of significance that tuber dormancy may impose on yields. In one experiment Allegany seed was subjected to three treatments: (CEHW) cut early and held warm at 15.6 C for 4 weeks; (CPHW) held warm at 15.6 C for 4 weeks and cut at planting; and (CPHC) held cold at 4.4 C, then warmed two days at 15.6 C and cut at planting. This trial was conducted on grower farms in Steuben and Wyoming counties and aver-

aged total yield increases of 30% and 18% for the CEHW and CPHW treatments, respectively. In three years of trials at our research farm, the CEHW treatment produced a 15% and 19% increase in total and marketable yields, respectively, for Allegany. In a similar trial with Allegany, Atlantic Superior and NY103, the CEHW treatment increased marketable yields by 15%, 29%, 11% and 14%, respectively. Tuber set, tuber weight and specific gravity of these four clones were not significantly affected by seed handling treatments. Note that Atlantic and Superior, with shorter tuber dormancy, also benefited from seed pre-warming and pre-cutting.

Hanneman, Robert E., Jr. *Techniques to Transfer Germplasm From 2X(1EBN) Mexican Species to 2X(2EBN) Material Via Hybridization*.

The 2x(1EBN) Mexican species are a rich genetic resource exhibiting extreme resistance to viruses, insects, fungi and nematodes. This group of species is unable to hybridize with other 2EBN diploid species and 2x(2EBN) Tuberosum haploids because of EBN. To use these species efficiently, means must be found to routinely create hybrids between 2x(1EBN) and 2x(2EBN) species and haploids. A hybrid has been created between a Tuberosum haploid and the Mexican species *S. pinnatisectum* using embryo rescue and second pollination techniques. Hybrids have also been generated using *S. verrucosum* as a bridging species. In addition, the *S. verrucosum* -2x(1EBN) Mexican species hybrids have been successfully crossed with 2x(2EBN) *S. phureja*, *S. chacoense* and a Tuberosum haploid. An efficient and effective means has been found to open the 2x(1EBN) gene pool to exploitation for potato improvement using common hybridization techniques coupled with knowledge of 2n gametes and Endosperm Balance Number (EBN).

Hanneman, R.E., Jr. and M. Ramon. *Evaluation and Pre-Breeding With New Sources of Resistance to Colorado Potato Beetle and Late Blight*.

As a part of the joint National Cooperative Enhancement Project, enhancement materials are evaluated for resistance to early blight, late blight, Colorado potato beetle in unsprayed plots and for early dying in an infected plot at the UW Agricultural Research Station at Hancock, Wisconsin. These tests augment routine evaluations for yield, chipping, specific gravity, adaptation, etc. A summary of 1998 field evaluation on over 1000 selections for early blight, Colorado potato beetle and early dying will be reported. A unique haploid x *S. pinnatisectum* hybrid was evaluated. It exhibits low

blight, respectively. Although each species is extremely difficult to cross directly with potato, we have obtained fertile somatic hybrids for use in breeding programs. In each case, we have also demonstrated that the disease resistance of the wild species can be recovered in sexual progeny of the hybrid crossed with potato breeding lines. With *S. brevidens* - derived materials, we have obtained evidence for introgression of wild species DNA into the potato genome. With *S. bulbocastanum* - derived materials we have obtained full resistance to late blight even in third backcross progeny. These results indicate that these lines, which we will provide to breeders on request, can provide a number of resistances that could be highly economically useful. During the next year we will cross key hybrids with potato breeding lines to preserve useful genotypes in progeny. However, at the present time we can still provide the fertile hybrids to breeders so that they can make the crosses with lines of their choice.

Honeycutt, C. Wayne, Georgette M. Trusty, and David B. Torrey. *Foliar versus Soil N Application to Potato: ¹⁵N Recovery, Growth, Yield, and Quality Relations*.

Only about 30-50% of N fertilizer applied to soil at planting is recovered by potato (*Solanum tuberosum* L.) under rainfed conditions in Maine. This unrecovered N represents a significant loss in profitability and a potential environmental concern. A field study was conducted in Newport, ME with cv. Atlantic to determine the most efficient method of supplying N to potato (i.e., foliar application, soil application, or some combination of both) and to determine if recommended N fertilization rates can be reduced through foliar application. Recovery of soil-applied ¹⁵N depleted ammonium sulfate ranged from 37 to 57%. Uptake of foliar ¹⁵N enriched urea ranged from 56 to 69%. Tuber yield ranged from 28 to 38 Mg ha⁻¹ when N was soil-applied, but only 21 to 31 Mg ha⁻¹ when foliar-applied. Greater root growth was observed for soil-applied N (228 kg root dry weight ha⁻¹) compared to foliar N (177 kg root dry weight ha⁻¹). Lower yield with foliar N may reflect the importance of soil-applied fertilizers for promoting root growth and thus water uptake. Although N use efficiency was greatest with foliar N, the observed yield penalty indicates foliar application is not a viable alternative to soil application of N to potato.

Ingerson-Mahar, Joe and M.R. Henninger. *Surveying Wireworms to Predict Damage in White Potatoes in New Jersey*.

Within the past 6 years, wireworms, particularly *Melanotus communis* (Gyllenhal), have become a problem in field

corn (*Zea mays*) and potatoes (*Solanum tuberosum*) in the Salem and Cumberland County area of southern New Jersey. Bait trapping, using a mixture of corn and wheat seed to attract wireworms, has become an effective way of determining whether wireworms are present in fields and how many prior to planting. Studying wireworm numbers in corn fields preceding potatoes has provided cultural recommendations to farmers to help lessen wireworm injury. Avoid planting potatoes in fields that have received dairy manure and have a history of continuous corn. Change the crop rotations to reduce or eliminate corn and small grains between plantings of potatoes.

Inglis, D.A., B.M. Gundersen, R.L. Ludy, and M.L. Powelson. *Preventive Versus Curative Applications of Potato Seed Piece Fungicides For Management of Seedborne Phytophthora infestans*.

Healthy and blighted potato tubers were cut into 2 oz seed pieces, treated with selected fungicides (Tops MZ @ 1 lb/cwt; Curzate M-8 @ 10,000 ppm a.i.; mancozeb @ 1 lb/cwt; Tops 5D @ 0.5 lb/cwt), and planted in the field at Mount Vernon and greenhouse at Corvallis. Healthy seed pieces were inoculated following fungicide treatment whereas blighted seed pieces were inoculated 7-10 days prior to treatment using US-11 on White Rose and US-8 on Russet Burbank at the respective locations. At Mount Vernon, emergence of inoculated vs. blighted seed pieces was 97 vs. 20, 99 vs. 22, and 97 vs. 8% for Tops MZ, Curzate M-8, and mancozeb, respectively. In contrast, emergence of inoculated vs. blighted seed pieces was 14 vs. 2, and 5 vs. 1% for Tops 5D and the nontreated control, respectively. Similarly at Corvallis, treatment of inoculated vs. blighted seed pieces resulted in 85 vs. 18, 65 vs. 14 and 55 vs. 6, and 11 vs. 2 and 1 vs. 2% emergence for the five respective treatments. Preventive application of a fungicide without activity against *P. infestans* as well as curative applications of fungicides with or without activity against *P. infestans* to seed pieces resulted in decreased emergence, lower area under the emergence progress curve and increased seed piece decay of emerged plants. Seed piece fungicides with activity against *P. infestans* need to be applied preventively rather than curatively for control of seedborne inoculum.

James, Steven R. *A Comparison of Two Winter Testing Schemes For Certifying Seed Potato Lots*.

Greenhouse and outdoor winter testing schemes for certifying seed potato lots were compared between 1995 and 1998. Samples taken from seed lots produced during the

1995, 1996, and 1997 growing seasons were obtained from central Oregon growers and divided into two size ranges. The 2-3 ounce (57-85g) tubers were planted at Oceanside, California (outdoor site), and the 4-6 ounce (113-170g) tubers were planted at Corvallis, Oregon (greenhouse site) and rated for viral infection by certifying agencies in Idaho and Oregon, respectively. The percentage of plants visually observed to be infected with Potato Virus Y (PVY) or Potato Leafroll Virus (PLRV) was nearly identical at each testing location in 1995-96 and 1996-97. In 1997-98, PVY infection was detected in the same lots at both winter testing sites, however, the percentage of infected plants varied inconsistently. Emergence averaged 73 percent at Oceanside and 96 percent at Corvallis over the three seasons the study was conducted.

James, Steven R., Dan C. Hane, Alvin R. Mosley, Kenneth A. Rykboost, and Clinton C. Shock. *A World Wide Web Database For Potato Breeding Selections*.

A database of potato variety trial results from testing sites in the western United States was developed. Database records contain plant and tuber characteristics, yield, grade, tuber internal and external defects, French fry color and quality, and disease evaluations. Included in the database are breeding selections tested in Oregon advanced statewide variety trials from 1987 to present, western regional variety trials from 1991 to present, and tristate variety trials from 1997 to present.

Variety trial data was placed in a Microsoft Access database and published on the World Wide Web using Active Server Pages. Web users can generate custom reports by selecting the breeding selection, testing site(s), year(s) tested, trial(s), and data desired. Plant and tuber photographs, descriptions and disease reactions for each breeding selection can also be accessed. Database information can be retrieved at <http://www.css.orst.edu/coarc/database.htm>.

Johnson, Alexander, A.T., A. Raymond Miller, and Richard E. Veilleux. *Agronomic, Leptine and Fertility Analysis of a Potato Somatic Hybrid and First Generation Progeny*.

A somatic hybrid (SH2) was produced by protoplast fusion between *Solanum phureja* monoploid 13-14 203 ($2n=1x=12$) and a monoploid CP2-103, derived from an F_1 hybrid between *S. chacoense* and *S. phureja*, to transfer leptines, a feeding deterrent of the Colorado potato beetle (*Leptinotarsa decemlineata* Say), to cultivated potato. SH2 ($2n=6x=72$) was pollinated with both *S. phureja* clone 66AP11-53 ($2n=2x=24$) and *S. andigena* clone 8-1 ($2n=$

$4x=48$) to yield SH2P and SH2A progeny, respectively. A replicated field trial consisting of 9 clones (SH2, 4 SH2P progeny, 2 SH2A progeny and cvs. Katahdin and Atlantic) was conducted in 1998. The two cultivars had the greatest total tuber yield (1.7 kg per plant) but did not differ significantly from one of the SH2P progeny. Tuber number per plant was similar for the two cultivars, SH2 and 4 of its progeny. The cultivars had the highest average tuber weight (152 g per tuber). However, 3 SH2P progeny exceeded the average tuber weight of SH2 (20 g per tuber). SH2 produced 7,256 $\mu\text{g mg}^{-1}$ dry weight of acetylcholinesterase (AChE). SH2 progeny produced AChE ranging from 995-4,740 $\mu\text{g mg}^{-1}$ dry weight for SH2P progeny to 1,996-3,034 $\mu\text{g mg}^{-1}$ dry weight for SH2A progeny. SH2P and SH2A progeny displayed increased fertility relative to SH2 and were crossed as both male and female parents to cv. Atlantic.

Joyce, P.J., K.F. McCue, W.R. Belknap, D.L. Corsini, S.L. Love, H. Groza, and B.D. Bowen. *Glycoalkaloid Levels in a Genetically Modified Lenape*.

Microtuber discs were used in the transformation of the variety Lenape by *Agrobacterium*-mediated gene transfer. The new transgenic lines contained an antisense solanidine glucose-ADP glucosyltransferase (SGT) transgene, with the intention of inhibiting the biosynthesis of tuber glycoalkaloids.

Thirteen transgenic lines of the variety Lenape were evaluated and characterized in replicated trials at two locations, Rhinelander and Aberdeen. In Aberdeen tubers from three transgenic lines had significantly lower glycoalkaloid levels than tubers of the variety Lenape. Glycoalkaloid concentrations of the transgenic lines ranged from 24.6 milligrams glycoalkaloids per 100 grams tuber fresh weight (mg/100 g FW) to 15.7 mg/100 g FW with Lenape at 22.2 mg/100 g FW. In Rhinelander, similar reductions were measured, but they were not statistically significant. Western analysis revealed lower levels of glycoalkaloids correlated with lower levels of the SGT protein. Northern analysis confirmed the presence of the antisense SGT RNA in the transgenic plants. Northern and Western analyses are consistent with the hypothesis that the antisense SGT gene inhibited the biosynthesis of the glycoalkaloids.

Kelling, K.A. and P.E. Speth. *Responsiveness of Russet Burbank to ACA Rate*.

Agricultural Crop Additive (ACA) is zinc ammonium acetate, contains 15% N and 17% Zn, and in some situations, has been shown to increase root growth, stress tolerance,

and crop yield. Yield responses with agronomic crops have been mixed; however, few experiments have been conducted with horticultural crops. We evaluated the use of several ACA rates (48 to 288 mL/ha) applied with the banded fertilizer at planting in each of 4 years on a Plainfield loamy sand (Typic Udipsamments, sandy, mixed, mesic), using a RCB design with six replications. A different set of plots was used in each year. In each of the years, at least one ASA rate (96 mL/ha in 1994, 48, 96, and 288 mL/ha in 1996; 192 mL/ha in 1997, and 288 mL/ha in 1998) increased total yield above a 0 ACA control ($P \leq 0.10$). Averaged over the 4 years, all rates increased total yield significantly or nearly significantly. Grade and size parameters showed some tendencies toward improvement with ACA, but results were very inconsistent. Early-season growth (vegetation weight, root weight, tuber number, tuber weight) did not show any consistent effect of the ACA additions, nor did mid-season leaflet and petiole nutrient analysis. While data from these experiments show general potato yield benefits from using ACA, no clear mode of action was identifiable.

Kelling, K.A. and P.E. Speth. *Effect of Harvest Date on Optimum N Rate For Norland*.

Previous research at Wisconsin showed that the optimum nitrogen rate for the variety Norland, when grown for full season on sandy soils, was very high (270 to 335 kg/ha). However, this red variety is often harvested early in an attempt to capture part of the early-season new potato market. This research attempted to identify the optimum N rate x harvest date relationship for Norland by applying various rates of N (0 to 270 kg/ha in 67 kg/ha increments) and harvesting the potato at three times (mid-July, mid-August, or mid-September). In all 3 years, the potato had senescence by 25 to 30 August, irrespective of N rate. Plots were laid out in split plots with harvest date as the main plot and N rate as the subplots in a RCB with four replications on a Plainfield loamy sand (Typic Udipsamments, sandy, mixed, mesic). In 2 of the 3 years of the study, the N rate x harvest date interaction time was significant for total yield, size, grade, and yield of US#1 170 to 370 g tubers. As expected, yield and quality were maximized with a lower N rate for the earliest harvest (135 kg N/ha), but required about 200 kg N/ha for the later two harvest dates. It is likely the data may have separated even more had we been able to keep the crop growing for the full season. Data from this experiment confirm that lower N rates may be used for early-harvested potato.

Kianian, Penny M.A. and Richard G. Novy. *The Development of Codominant Sequence Tagged Site Markers From RAPD Heteroduplexes*.

Random amplified polymorphic DNA (RAPD) markers have been used extensively in the plant sciences for genetic analyses. RAPDs typically have a dominant mode of inheritance, however, the occurrence of codominant RAPDs has been reported in a number of plant species. These codominant RAPDs result from the amplification of "allelic" DNA segments that differ by the insertion, deletion, or substitution of base pairs between their primer annealing sites. During PCR amplification, the DNA strands of each codominant marker may reanneal to form two homoduplexes and two heteroduplexes. The migration of hybrid heteroduplex molecules during non-denaturing electrophoresis differs from the homoduplex bands from which they originate.

While confounding in genetic analyses, RAPD heteroduplexes also provide a means of identifying codominant RAPDs. Once identified, codominant RAPDs can be cloned and sequenced, and primers specific for their amplification designed—effectively converting a codominant RAPD to a sequence tagged site (STS) marker.

We report on the identification and cloning of two codominant RAPDs that were identified based on their formation of a heteroduplex band. The two codominant RAPDs were sequenced and found to have 83% homology with one another. The major difference between the two RAPDs was a deletion of 26 bp within the smaller fragment. These RAPDs were converted to STS markers following the design of 20-mer primers specific for their amplification at higher annealing temperatures.

This research provides a new approach in the development of codominant molecular markers similar to SSR's, but without their difficulty in identification and development. The development of additional STS markers using this approach is ongoing.

Kirk, William W., Jeffery M. Stein, Robert L. Schafer, and Brendan A. Niemira. *Efficacy of Azoxystrobin Against Potato Late Blight*.

Azoxystrobin (Quadris®, Zeneca), a novel fungicide from the strobilurin class, was tested over three years in field trials inoculated with *Phytophthora infestans* and in controlled environment studies. Dose response studies conducted in the field confirmed functional application rates between 0.225 and 0.337 kg a.i./ha. when azoxystrobin was applied prophylactically. Studies in which azoxystrobin was applied after

test plots had been inoculated showed that azoxystrobin suppressed late blight up to 72 hours after inoculation but not after late blight became established. Controlled environment studies to establish the duration of efficacy of azoxystrobin will be reported.

Kirk, William W., David Douches, Brendan A. Niemira, and Jeffery M. Stein. *Combining Varietal Resistance With Managed Fungicide Applications For The Control of Potato Late Blight*.

Durable resistance was defined as production systems that utilized potato cultivars with reduced susceptibility to late blight in combination with managed fungicide applications. Experiments to control late blight using fungicides in combination with heritable host resistance using reduced amounts of fungicide (combinations of extended intervals and reduced dose rates) and with lower amounts of active ingredient fungicides were continued from trials conducted in 1997. Reduced levels of fungicide applications resulted in less foliar disease when combined with varietal resistance. The novel fungicide Fluazinam was effective at 33% of recommended rates on all varieties tested. The conventional fungicide Bravo WS was effective at 33% of recommended rates on the moderately susceptible cultivars. Both fungicides were effective at 67% of recommended rate on all varieties. Reducing the application rate of Bravo WS 6SC from 100 to 67 and 33% (7 day interval) caused increases in foliar disease. In varieties less susceptible to late blight, the magnitude of the difference was negatively correlated and little response to fungicide application was noted. MSG274-3, was the least susceptible variety in a separate trial.

Kiru, Stefan and N.I. Vavilov. *Solanum Andigenum Juz. et Buk. As Basic Material For High Starch Potato Breeding*.

A cultivated South American tetraploid specie *Solanum andigenum* is a highly polymorphic and a rich source of valuable genetic, agronomic and breeding traits. A high starch content in potato tubers is one of these traits. During the period of 1994-1998, 35 potato genotypes - sources of high starch content were distinguished after a progeny evaluation of 406 samples from, which include 96 forms - varieties of *Solanum andigenum*, from various South American countries. A high fertility of *S. andigenum* makes it possible to use this specie in different combinations of crosses with many potato species and cultural varieties. A character of inheritance of high starch content and general combining ability were also determinated in the progenies derived from

self-pollination and crossing with cultural varieties and wild species.

On testing of F1 and back crossing progenies high starch content genotypes with high inheritance coefficient were selected. Among them there were Peruvian forms: *herrerae*, *rayancachense*, *ccompis* and *ccompetillo*, Columbians ones: *caiceda* and *tocanum*, and *tungurahense* from Ecuador. On crosses between above mentioned forms with *S. cha-coense*, f. shikki, f. gibberillosum and *S. demissum* up to 55 % of seedlings with starch content more than 25% were observed. Also above-mentioned *S. andigenum* forms were crossed with high content cultural varieties Bison, Saturna, Hertha, Milda and Ogonjok. In this case, about 46% of seedlings had the same high starch content. As the result of our investigations several selected clones will be integrated into further breeding programs on development of high starch content potato highbreds and varieties.

Kline, Wesley, Melvin Henninger, and Stephen Johnston. *Hybrid Sudangrass to Control Nematodes Before Planting Potatoes*.

Hybrid sudangrass (cv. Trudan 8) has been shown to suppress nematodes in some areas when the plant material is incorporated into the soil. New York research demonstrated that mowing once during the growing season stimulated tillering, prevented development of woody stems, and promoted deep root growth.

An experiment was established to compare the cultivar Trudan 8 to small grain stubble in suppressing lesion nematodes (*Pratylenchus penetrans*). Plots were arranged in a randomized complete block design with six replications. Sudangrass (25 lbs/A) was no tilled into pre-irrigated soil in July 1997. Plots were topdressed with 50 lbs/A nitrogen and one-half of each sudangrass plot was cut to 8-10 inches in August 1997. All plots were mowed, moldboard plowed and the soil sealed with a cultipacker in October 1997.

The potato cultivar Superior was planted in spring 1998 and harvested August 1998. Soil samples were collected three times during the study to determine what effect the sudangrass had on nematode populations. Forage samples were collected from the cut and uncut subplots to determine fresh and dry weights.

There was no statistical difference in either fresh (22.4 tons/A cut and 22.5 tons/A uncut) or dry (3.9 tons/A cut and 4.0 tons/A uncut) forage yields. There were more lesion nematodes in the sudangrass plots (90.6/250 cc of soil) versus (65.6/250 cc of soil) the stubble when the three sampling

dates were averaged. The nematode population did increase with each sampling date, but did not reach damaging levels (> 100/250 cc of soil) until potato harvest. Potato yields and grades were similar for both treatments with 298 cwt/A in the sudangrass plots and 317 cwt/A grain stubble.

Kuhl, J.C., R.E. Hanneman, Jr., and M.J. Havey. *Resistance to Phytophthora infestans in Diploid Solanum Species of Mexico and South America*.

Two diploid *Solanum* species from central Mexico and eight diploid species from northwestern South America were evaluated. Replicated detached leaf assays using the *Phytophthora infestans* isolate MSU 96 (US-8 A2) were used to score infected leaf area on a scale of 0 to 9. Visual identification of hypersensitive reactions were based on morphological characteristics of the disease reaction. For genetic characterization of a resistant *S. pinnatisectum*, a resistant F_1 interspecific hybrid was backcrossed to the susceptible *S. cardiophyllum* subsp. *cardiophyllum* parent. According to the segregation data, few loci contribute to resistance in this *S. pinnatisectum* accession, which comes from a region of complex and diverse *P. infestans* populations in Central Mexico. Additional sources of resistance were identified in the distantly related diploid species from the Advanced Rotata (Hawkes) of northwestern South America. Hypersensitive reactions were also identified, concentrated in specific accessions of some of these South American species. This resistance comes from species of a region traditionally not associated with the pathogen *P. infestans*.

Laferriere, Louise, Caitilyn Allen, and John P. Helgeson. *Bacterial Wilt Resistance From Solanum Commersonii: Strain Specificity and Systemic Colonization By Ralstonia Solanacearum*.

S. commersonii is a potential source of bacterial wilt resistance in potatoes. We have obtained resistant BC1 and BC2 lines from a resistant *S. tuberosum* + *S. commersonii* somatic hybrid. In order to test the possibility that resistant plants are merely tolerating higher bacterial populations, we investigated systemic colonization in the stems of the *S. tuberosum* parents, the *S. commersonii* fusion parent, the somatic hybrid and the BC1 lines. When plants were diseased, bacterial populations in the stem were invariably high. No line tolerated high populations of bacteria in their stems, regardless of resistance level. Resistance is strain specific. Of the twelve strains of *R. solanacearum* we tested, two race

1/biovar 1 strains overcame *S. commersonii* resistance. *S. commersonii* expressed resistance to the remaining genetically diverse strains, including three other race 1/biovar 1 strains.

Lamont, William, Michael Orzolek, Lew Otjen, and Terry Simpson. *Production of Potatoes Using Plastic Mulches, Drip Irrigation and Row Covers*.

Seed pieces of two varieties of potatoes, NY101 and Dark Red Norland were hand-planted 8 inches apart on raised beds covered with three colors of plastic mulch-red, silver, black or no mulch on April 22, 1998 at the Horticulture Research Farm, Rock Springs, PA. Prior to making the beds and applying the plastic mulch and drip irrigation tape, 640 lbs/A of 10-10-10 was broadcast on the field. Spacing between the mulched beds was 6 feet. Drip irrigation was used with all treatments and the potatoes were fertigated throughout the season. Typar, a floating row cover material, was applied on April 22nd to half of each treatment. Standard pest management practices were utilized throughout the growing season. Dark Red Norland and NY101 were dug on August 5 and 24, respectively. Although, there was a clearly observable increase in growth of the potato plants there was no significant effect of row cover on yield of either variety. All mulches significantly increased yields compared to bare ground. Only yields of Dark Red Norland showed a statistical significant difference between mulch color with silver and red being higher than black. Silver mulch resulted in highest yields for both varieties of potatoes.

Landeo, Juan A. and Manuel Gastelo. *Heritability of Horizontal Resistance to Late Blight in Breeding Population B At The International Potato Center*.

Population B is a potato breeding population under improvement for horizontal resistance to late blight in absence of major genes (R genes) for vertical resistance. Other important agronomic and quality traits for table and industry use, resistance/tolerance to other important biotic stresses and, adaptation to major agro-ecological zones in developing countries are also taken into account. Genetic variability for horizontal resistance to late blight is under continuous monitoring to ensure progress from selection through recombination cycles. During 1998, progenies of a random sample of resistant clones from cycle 1 (B3C1), obtained by NC design I (D-I) and Line x tester (LxT), were evaluated for late blight resistance and total tuber yield. Filed

designs RCB and simple lattice with two 2 replications and 30 individuals plot sizes were used respectively. Three independent estimates of heritability including PO-regression for the area under the disease progress curve AUDPC, taken as a parameter for resistance, resulted in very close values ($h^2 = 0.48$, $h^2 = 0.53$, $h^2 = 0.40$) indicating consistency of these estimates. It also indicates that the additive genetic variance is still important and large enough to ensure further progress from selection. Implications in population breeding will be discussed.

Leiby, James and Scott Kenney. *Variable Packing Costs*.

Based on a small-scale survey, costs of packing tablestock potatoes for packers of a range of volumes are estimated. These costs are developed for various potato packs from a computer model of different sized packing operations. We consider packing costs for three different size classes of packers—small, 60,000 cwt. to 99,000 cwt./year; medium, 99,001 cwt. to 200,000 cwt./year; and large 200,001 cwt./year and above, and 4 different packs: 5# and 10# paper, and 5# and 10# poly bags, including bailed and unbailed packs. Costs are considered for equipment operation, raw materials, labor, fuel and power. Ownership costs are not considered in this analysis.

Per cwt. costs are highest for the mid-sized packers because of greater per-unit labor costs than smaller scale operations, and higher bag costs than the larger sized operations. Further the use of computerized weigher-baggers reduces both the potato overage and labor costs for the larger sized operations.

Leiby, James and Steven Belvea. *The Weekly Costs of Potato Storage*.

Estimates of week-to-week storage costs for tablestock and processing potatoes as well as cold storage costs are performed. With such numbers the profitability of the time in storage can be calculated and delivery contracts may more adequately reflect the costs to growers. The costs presented include only the costs that depend on the time that the potatoes are in storage and ignore completely ownership costs of the storage, including the capital (interest depreciation, etc.) costs of the building, maintenance, taxes, building insurance, etc. since these costs should not affect the decision of how long to store.

Shrink and loss, and interest costs together make up the about two-thirds of these week-to-week costs. Shrink and loss as well as electricity costs vary through the storage sea-

son, and the costs of interest and shrink and loss depend on the market value of the crop. Sensitivity analysis of the assumptions of the models is performed.

Lozoya-Saldaña, Héctor and A. Hernández-Vilchis. *Three Year Evaluation of International Potato Clones For Resistance to Late Blight in the Toluca Valley, Mexico*.

Toluca Valley is the place of choice to test genetic resistance to late blight (*Phytophthora infestans*) for several reasons: a) it is the natural environment for the two mating types of the fungus, b) and consequently, all known pathogenic races are present every year, c) a number of wild *Solanum* species host the pathogen, and d) these highlands have the ideal climate for development of the disease. In 1998, 103 out of 330 clones from previous years and 415 genotypes from 4089 new entries were selected for further evaluations. Selection in 1998 was based on less than 40% foliar infection and more than 800 g tuber/plant, although in 1996-1997 such criteria were not considered. Several outstanding new materials had only about 10% foliar infection at the end of the cycle. The clones were from Wisconsin (Madison and Sturgeon Bay), Idaho, Washington State, Ithaca, the Netherlands, the National University of Mexico, and Ireland. Cultivars from the Genotype x Environment program were also included, although not for selection purposes.

Lozoya-Saldaña, Héctor and A. Hernández-Vilchis. *Fungicide Trials With Registered and Section 18 Compounds For Control of Late Blight in 1997-1998 in Toluca, Mexico*.

In 1997 Toluca was included as one of 13 locations where seven protective fungicide programs of combined registered and section 18 products applied as weekly foliar sprays were evaluated for control of late blight (Inglis D.A. *et al.*, Am J Potato Res 75:279, 1998). The trial was repeated in Toluca in 1998. Susceptible cultivar Alfa was included in the two years of testing. As usual, a great variability of physiological races of the pathogen were present, and the control plots with no chemical control were 80 to 90% infected before the end of the season. All programs reduced the incidence of the pathogen, and no significant differences in foliar infection levels were detected among treatments. There were differences, though, when any program was compared to the control with no fungicides. Effectiveness of treatments to control the disease fluctuated between 71% and 94% in 1997, and 63 and 89% in 1998. Considering the value of the harvested tubers and the cost of the programs, the decision of which program to

adopt may be based on yield. Programs including section 18 compounds outperformed registered products.

Ludy, R.L. and M.L. Powelson. *Distribution of Tubers With Late Blight Within A Potato Hill.*

Potato cultivars Atlantic, Katahdin, Kennebec, Red La Soda, Russet Burbank, Sebago, and Shepody were planted in the field at Corvallis, OR in June 1998. Foliar symptoms of late blight first appeared throughout plots on 28 Aug. At this time the plant canopy was sprayed once with Dithane to slow the progress of the epidemic. Tubers were harvested weekly beginning 3 Sep and placement of each tuber within a hill was established by measuring stolon length and depth. Tubers were assessed for symptoms of late blight. Tubers without symptoms were surface sterilized and incubated at 18 C for 1 wk and then evaluated. At the first harvest, the average incidence of tuber blight was 3% when foliar symptoms averaged 9%. Another 6% of the tubers developed symptoms after incubation. Proportion of diseased tubers increased to 19% by the 3rd harvest when foliar symptoms averaged 64%. Another 4% of the tubers developed symptoms after incubation. Cumulative incidence of tuber blight ranged from a high of 29% for Red La Soda to a low of 9% for Russet Burbank. Differences among cultivars were not significant for percent tuber blight at harvest and after incubation, as variability was high. Statistical comparisons on stolon length and depth of blighted versus healthy tubers from the same hill did not reveal any differences. Overall, however, proportion of diseased tubers increased as stolon length ($p=0.006$) and depth ($p=0.009$) decreased. Percent of tubers with late blight were 33, 28, 22, 21, 9, 6, and 24% for stolon lengths of <2.5, 3-4.5, 5-6.5, 7-8.5, 9-10.5, 11-12.5, >13 cm, respectively. Percent of tubers with late blight were 42, 33, 23, 18, 22 and 25% for tuber stolon depths of <4.5, 5-6.5, 7-8.5, 9-10.5, 11-12.5, >13 cm, respectively.

Lulai, Edward C. and Thomas P. Freeman. *Relationships Between The Deposition of Suberin Polyphenolic and Polyaliphatic Domains During Tuber (Solanum tuberosum L.) Wound-Healing.*

Suberin is a protective biopolymer that is deposited on phellem cell walls of potato tubers during growth and wound-healing. Although suberin is known to be composed of complex polyphenolic and polyaliphatic domains, little is known about the biochemistry initiating and integrating the accumulation of these two domains. Earlier, we demonstrated the importance of these two domains by showing that

deposition of the polyphenolic domain alone conferred resistance to infection by bacterial pathogens causing soft rot. However, resistance to fungal pathogens causing dry rot did not appear until after suberin polyaliphatic deposition. We have histochemically monitored the deposition of the two suberin domains during tuber wound-healing and we have adapted a simple method to chromatographically fingerprint suberin aliphatic accumulations in native periderm and developing wound periderm. These results, together with corresponding inhibitor studies and previous research, show that suberin phenolic deposition is histochemically detectable in wound-healing cell walls well in advance of suberin aliphatic deposition. However, unincorporated suberin aliphatic material is chromatographically detectable within the periderm before it begins to accumulate in suberizing cell walls. Several inhibitors of suberin polyphenolic deposition were tested and the results indicate that suberin polyaliphatic deposition is coupled to the preceding polyphenolic deposition. These results are important in determining how suberization processes are initiated and integrated in potato tuber to prevent disease.

McBeath, Jenifer Huang, William Kirk, and Brendan Niemira. *Biological Control of Late Blight Infested Seed Pieces by Trichoderma Atroviride.*

Phytophthora infestans is an extremely aggressive plant pathogen. Under high relative humidity and with a temperature range of 4 to 26 C, *P. infestans* can cause severe late blight disease on potato plants and tubers. Increasing evidence indicates that seed-borne late blight, especially on healthy seed pieces which become infested during pre-cutting, plays a significant role in disease establishment and dissemination. Management of late blight relies on complete and repeated coverage of foliage with fungicides. No effective seed piece treatment is presently available. *Trichoderma atroviride* is a versatile, aggressive hyperparasite that can parasitize a wide spectrum of pathogenic fungi, including *P. infestans*. It has a temperature range of 4 to 33 C and prefers high humidity. Treatments of seed pieces with *T. atroviride* after the freshly cut surfaces were inoculated with large numbers of *P. infestans* zoospores, improved potato emergence significantly. When potato discs received inocula of *P. infestans* in one pole and treatment of *T. atroviride* in another, late blight disease development in discs, as indicated by necrosis of cells, was more suppressed than in those without *T. atroviride* treatments, although no direct contact between *T. atroviride* and *P. infestans* was observed. A

direct correlation was found between intensity of disease suppression and *T. atroviride* population. Hyperparasitism and induced resistance seemed to be two of the mechanisms involved in the late blight suppression.

Mohammed, A., D. Douches, W. Pett, E. Grafius, J. Coombs, Liswidowati, W. Li. and M.A. Madkour. *Evaluation of Potato Tuber Moth Resistance in Tubers of BT-CRY5 Transgenic Potato Lines.*

The potato tuber moth, *Phthorimaea operculella* (Zeller) is the most destructive pest of cultivated potato in tropical and subtropical countries. The codon-modified *Bt-cry5* gene, transformed and expressed in potato, should provide host plant resistance to Lepidoptera and Coleoptera pests. The purpose of this study was to evaluate the efficacy of the *Bt-cry5* transgene to control the potato tuber moth in tuber tissues. Tuber bioassays using eleven to twelve-month-old stored and newly harvested tubers of *Bt-cry5*-Lemhi Russet and *Bt-cry5*-Atlantic potato lines showed up to 100% larval mortality, excluding the newly harvested tubers of *Bt-cry5*-Atlantic lines which shown a mortality range from 47.1% to 67.6%. Spunta, an economically important potato cultivar in Egypt, was previously transformed with three different *Bt-cry5* gene constructs. Potato tuber moth mortality was 100% in the lines that were transformed with *Bt-cry5* gene controlled by the CaMV 35S promoter (pBIML5 vector), and two of three lines transformed with *Bt-cry5* gene controlled by the Gelvin super promoter (pBIML1 vector). The transgenic line expressing *Bt-cry5* under the control of the patatin promoter (pBMIL2 vector) showed the lowest tuber moth mortality (25.6% and 31.1%). The *Bt-cry5* transgenic lines with high tuber expression of Bt have value as host plant resistance in an integrated pest management system to control potato tuber moth.

Morgan, Gaylon D., Tim R. Connell, Ann E. MacGuidwin, and William G. Schmitt. *Pest Distribution Within Production Potato Fields.*

The spatial distribution and movement of pest into or within production potato fields provide important information for strategic pest management. The aggregated distribution and low mobility of nematodes, Verticillium, and Early Blight provide optimum opportunity for localized management. Localized management benefits producers by increasing economic efficiency and reducing pesticide use. The objective of this research is determining the spatial distribution of pests within potato production fields.

Morgan, Gaylon D., Tim R. Connell, and William G. Schmitt. *Estimation of Weed Distribution And Potential For Variable Rate Management.*

Environmental concerns regarding pesticide use and issues of economic efficiency have promoted the use of precision agriculture in many realms of agriculture, including weed science. Weed management is a major concern in potato production due to limitation in labeled herbicides, harvesting complications, and yield loss. The objectives of this research were to determine the weed distribution in a potato production field, the affect of grid size on the estimation of weed distribution, and the influence of weed density and distribution on potato yields.

Murphy, Agnes, Henry De Jong, and Kenneth Proudfoot. *F87084: A Fertile, Adapted Clone With Multiple Disease Resistances.*

Genetic plant resistance is one strategy for minimizing the effects of disease. Sources of resistance to most pathogens are known to exist among various wild and cultivated potatoes. Classical breeding programs have striven to transfer these sources into cultivars for many years. Disease resistance is one of many attributes including adaptation, consumer quality and appearance that must be combined in a new cultivar before it is accepted and grown on any scale. F87084 has resistance to several pathogens which can be traced back to diverse germplasm sources. The development of this adapted, fertile germplasm selection will be used to demonstrate the assembly of many desirable traits that is possible through traditional breeding methods.

Naess, S.K., S.M. Wielgus, J.M. Bradeen, G.T. Haberlach, and J.P. Helgeson. *Introgressing Late Blight Resistance From Solanum Bulbocastanum Into Potato.*

Although resistance to late blight does not exist in potato cultivars currently grown in the U.S., it has been captured from the wild diploid *Solanum bulbocastanum* by somatic hybridization between a tetraploid potato and *S. bulbocastanum*. This resistance has been passed on through 3 backcross generations to potato. Homeologous recombination between the genomes of potato and *S. bulbocastanum* is essential for the eventual successful introgression of resistance and the efficient reconstitution of the recurrent parent. Three to one segregation ratios of dominant *S. bulbocastanum* specific RAPD markers in several BC2 populations as well as the presence of both alleles of codominant *S. bulbocastanum* specific RFLP markers in BC1 progeny of the somatic hybrids pro-

vide evidence that some homeologous pairing between genomes does in fact occur in the hexaploid somatic hybrids.

Niemira, Brendan A., William W. Kirk, Jeffery M. Stein, Robert Schafer, and Roger Brook. *Chlorine Dioxide Treatment of Potato Disease Complexes* (Phytophthora infestans, Fusarium Sambucinum, Erwinia Carotovora): In Vitro and In Vivo Efficacy.

Chlorine dioxide was tested for efficacy against late blight (*P. infestans*), fusarium dry rot (*F. sambucinum*) and soft rot (*E. carotovora*) under in vivo (potato tuber) and in vitro (selective media) conditions. Chlorine dioxide (150 ppm) was applied to whole tubers and wounded tubers inoculated with the pathogens singly and in combinations. Treated tubers were stored under disease conducive conditions in controlled environment chambers. While wounding led to greater overall disease development, chlorine dioxide was not effective in either whole or wounded tubers against any pathogen/pathogen complex tested. Pathogen/pathogen complex response to in vitro treatment with chlorine dioxide will be discussed.

Novy, Richard and Craig Longtine. *Introgression of Virus Resistance From Solanum etuberosum to Cultivated Potato*.

An increased incidence of potato leafroll virus (PLRV) and Potato Virus Y (PVY) has been observed in seed and commercial fields in recent years. The expansion of these virus diseases are thought to result from an increased use of fungicides for late blight control and the spraying of insecticides for the control of other insects such as Colorado potato beetle. Both production practices can "flare" aphid numbers, thereby increasing the transmission of PVY and PLRV which are vectored by aphids.

Solanum etuberosum (PI# 245939) has been identified as being immune to PVY and PVX, and highly resistant to PLRV. Tetraploid potato hybrids with *S. etuberosum* in their pedigree have been screened for resistance to PVY and PLRV, and have displayed high levels of heritable resistance to both viruses. *S. etuberosum* hybrids displayed 1/4 to 1/3 the PVY titer of the susceptible cultivar Atlantic, and approximately half the titer of moderately resistant Katahdin when assayed over a two year period using ELISA. Five of six *S. etuberosum* hybrids challenged with PLRV infected aphids were as resistant or more resistant than the PLRV-resistant cultivar Cascade. The results from field and greenhouse evaluations of these hybrids for virus resistance will be presented. At this time, third generation progeny of *S. etubero-*

sum and *S. tuberosum* have been obtained, and selections from this generation will be made in 1999.

Olsen, Nora, Robert Thornton, Andre Baritelle, and Gary Hyde. *The Effects of Storage on Physiological and Physical Characteristics of Seed Tubers*.

Seed tuber storage conditions can influence seed physiological age, sprouting capacity, biochemical status and tissue physical properties. The influence of storage temperatures (pre-storage, 3 C, 7 C and 9 C) and controlled atmosphere (CA) conditions (7 C, 2% O₂, 10% CO₂) were evaluated relative to the physiology and mechanical tissue properties of potato seed tubers (cv. Shepody). Typical model prediction ascribes lower tissue toughness to greater tissue turgor. In this study, tubers prior to storage (dormant) actually had high relative tissue turgor (wave speed) as well as high tissue toughness. Stored tubers generally responded to the model assertion with greater tissue toughness corresponding to lower relative tissue hydration levels. The pre-storage tubers may be exhibiting characteristics of stronger cell walls as indicated by the mechanical properties and independent of tissue turgor.

Tissue toughness was lower at the bud compared to the stem end only for pre-storage tubers and tubers stored at 9 C. No differences between bud and stem end were evident in tubers from 3 C, 7 C and CA storage. Tubers stored at 3 C had the lowest tissue toughness value. Measurements of tissue mechanical properties indicated changes occurred due to storage conditions and seed tuber aging.

Tubers removed from CA storage had similar physiological (sugar and starch content) and physical properties as tubers from 3 C storage yet had a greater capacity for rapid sprouting indicated by more advanced sprouting upon removal from storage. A trend for tubers with a lower sugar content to have a higher tissue toughness was observed with the pre-storage tubers and 9 C stored tubers compared to the other storage treatments. Tuber sugar composition may be more of an indicator of how the tubers were stored and therefore correspond or coincide with the tissue physical properties.

Oltmans, Shannon M. and Richard G. Novy. *Development of Cold Chipping Potato Cultivars By The Use of Wild Species*.

Potatoes used for chips are typically stored at temperatures ranging from 10-15 C. Storing tubers at lower temperatures (3 - 4 C) would decrease the incidence of storage disease such as silver scurf, and reduce tuber shrinkage and

sprouting. However, at these lower temperatures, there is an accumulation of reducing sugars (i.e., glucose and fructose) that result in commercially unacceptable chips. Progress has been made by potato breeders in the development of cultivars that resist the accumulation of reducing sugars at storage temperatures of 6-8 C. However, there are currently no potato cultivars that can be chipped from long term storage at <6 C.

Maximization of the benefits of cold storage could be realized if storage temperatures for chipping potatoes could be lowered to below 6 C. Plant material with cold-chipping characteristics was found in haploid x wild species families provided by the USDA/ARS National Cooperative Enhancement Project. In 1997, tubers of 142 potato hybrids were harvested from a single site and stored at 3 C for 15 weeks and 1) directly chipped, or 2) chipped following 2 weeks reconditioning at 18 C. Of the 142 hybrids evaluated, 12% and 80% from direct and reconditioning, respectively, were acceptable to marginal for chip color based on industry standards.

In 1998, the hybrids were grown at two sites, and harvested tubers were again evaluated for chipping characteristics following storage at 3 C for 15 weeks. Hybrids have been identified that chipped acceptably in both 1997 and 1998. Tubers of *S. raphanifolium* hybrids displayed the best chip color. The haploid x wild species hybrids and wild species clones were crossed with adapted potato cultivars and selections in 1998. Twenty-three plants from three families tubers were grown and were harvested. These putative tetraploids will be planted in the field in 1999 and evaluated for their agronomic characteristics and their ability to chip from long-term storage at 3 C.

Platt, H.W. (Bud) and F. Daayf. *Canadian Populations of Phytophthora infestans in 1998*.

About 340 potato samples suspected of having late blight were collected from the ten Canadian provinces in 1998. *Phytophthora infestans* was isolated from 81% of these samples. In comparison with 1997, there were 151 more samples received, 160 more late blight-infected ones, and five more provinces were represented in 1998. This study was conducted to determine the different changes in *P. infestans* populations across Canada. Assessments included pathogen isolate mating type, level of resistance to metalaxyl, and glucose phosphate isomerase (Gpi) patterns. A2 was the only mating type found in all provinces for which samples were tested except for two provinces; for samples from British Columbia 20% of the isolates were A1 while from Quebec one

A1 isolate was found. Metalaxyl resistance variations within the Canadian populations based on the relative growth of isolates on three metalaxyl concentrations (1, 10, and 100 ug/ml) will be presented. Generally, the results demonstrated a decrease in resistance to metalaxyl of the A2 mating type populations. Finally, results of Gpi-allozyme patterns found in these populations will be described but in summary the US-8 pattern was the most common found across the country. Conclusions will also be presented regarding the general shifts in the Canadian populations of *P. infestans* during the last few years and the implications that these findings may have on the potato industry.

Platt, H.W. (Bud) and F. Daayf. *In Vitro Responses of Canadian Phytophthora infestans Isolates to Common Late Blight Fungicides*.

Thirty isolates of *Phytophthora infestans* collected from five Canadian provinces in 1997, from both potato and tomato plants, were tested for their relative growth on culture media with or without fungicide amendments. Rye agar culture medium was amended (or not) with one of the following fungicides: Acrobat, Dithane, Curzate, Bravo and Tattoo-C, at four different concentrations: 0.5, 1, 2.5, and 5ug/ml. Relative growth of isolates was compared with each fungicide-amended medium on the basis of the isolates' province of origin, mating type, Glucose-phosphate isomerase (Gpi) allozyme pattern, and host or origin. Bravo and Tattoo-C were able to repress growth of *P. infestans* isolates at all concentrations for almost all isolates tested. Isolates from Manitoba were the most resistant to Dithane and Acrobat, while there was no significant difference between provinces in terms of resistance to Curzate. A1 mating type isolates were more resistant to Curzate than A2 ones but there was no significant difference between mating types in terms of growth in rye agar amended with Acrobat. For Dithane, A1 isolates were more resistant than A2 isolates at both 0.5 and 1ug/ml but A1 was less resistant than A2 at 5 ug/ml. Among Gpi-allozyme genotypes, US-11 was the most resistant to Curzate, while UN-4 and US-8 were the most resistant to Dithane. No significant differences were recorded between genotypes with Acrobat.

Riebe, Jennifer. *Aphid Management in PLRV and CPB-Resistant Newleaf Plus Potatoes: Insecticide-Free Production in the Pacific Northwest*.

NatureMark's NewLeaf Plus Russet Burbank potatoes are genetically modified for resistance to the Colorado potato

beetle (CPB) and potato leafroll virus (PLRV), which is vectored most commonly by the green peach aphid (GPA). Without the need for intensive insecticides to limit virus spread, it is anticipated that beneficial insects alone may maintain pests at acceptable levels. NewLeaf Plus potatoes were grown commercially at 11 sites in ID, OR, and WA in 1998. None of the fields were treated for aphids or CPB. Beneficial insects appeared to be responsible for lower mite populations in NewLeaf Plus fields. Growers recognized an average chemical savings of \$95.45/acre in the Columbia Basin of OR and WA, and \$40.71/acre in Idaho.

Rivera-Peña, Antonio, I. Sanchez-Valdez, G. Garza-Falcon, and L.J. Yepes-Padilla. *Paz Blanca: A New Variety of Potato Resistant to Late Blight and Good Chipping Quality*.

PAZ BLANCA (77-70-91) is an oval white potato selected from a cross between WIS-BR-63-65 and JUANITA made in 1977 and will be released by the INIFAP-CIRCE-CE-VALLE DE TOLUCA in 1999. It is a medium late variety, with uniformly sized tubers. The smooth skin has shallow eyes well distributed on the tuber and it has cream flesh. PAZ BLANCA produces medium to high yield, comparable to ALPHA. The tuber is very similar to Alpha in appearance. Specific gravity averages 1.075. It has processing and fresh markets potential. Its internal quality is a little better than ALPHA. It is resistant to late blight under natural attack in the field by a complex population of races of *Phytophthora infestans*. The new variety have been tested in regional trials in four localities in Mexico from 1993 to 1997. PAZ BLANCA as an alternative of an innovative technology to the farmers will be discussed.

Rojas-Cifuentes, G.A. and R.G. Novy. *RAPD Heteroduplex Formation in Potato And Its Impact on Genetic Distance Estimates*.

RAPDs have many positive attributes for inclusion in a breeding program, and have been used extensively for genetic analysis in agricultural crops. Typically having a dominant mode of inheritance, codominant RAPDs have been reported in several plant species as well. Codominant RAPDs are typically found at the same chromosomal site and have high sequence homology to one another; however, they differ by the insertion, deletion or substitution of base pairs. During the polymerase chain reaction, the DNA strand of one codominant marker can reanneal with the DNA strand of the other "allele" to form a heteroduplex molecule. These hybrid DNA molecules migrate more slowly during electrophoresis

than the codominant markers. Subsequently, heteroduplex can be scored as unique markers when they are actually artifacts of the RAPD procedure. Heteroduplex formation between codominant RAPDs can, therefore be a confounding factor in the use RAPDs.

In order to assess the frequency of RAPDs heteroduplex formation in potato, the DNA of 38 haploid potato clones was amplified using RAPD primers. The DNA of individuals lacking a RAPD allele were then intermixed in equal parts and reamplified to determine if the missing marker could be recreated; evidence that it is a heteroduplex artifact. Based on this assay, 25 of 62 (40%) RAPDs at this time have been identified as heteroduplex artifacts.

Using (1) all the RAPDs (including heteroduplexes) identified in the haploids and (2) only nonheteroduplex RAPDs, genetic distance estimates were calculated for the 38 potato haploids. The two datasets of genetic distance estimates were used in constructing dendrograms that allow for direct comparisons of relationships among the analyzed clones in each of the two datasets. Correlation coefficients were also calculated between the two genetic distance matrices in order to assess the impact heteroduplexes have on genetic distance estimates.

Ronald, Andrew and M.K. Pritchard. *Effect of Desiccation on Yield, Process Quality, And Late Blight Tuber Rot Development in Manitoba Grown Russet Burbank Potatoes*.

Vine killing is practiced in most production areas to increase harvest efficiency and reduce the potential for tuber infection by late blight at harvest. With yields already limited by a short growing season, Manitoba growers have been reluctant to adopt this practice. In a two year study, Russet Burbank potatoes were desiccated with diquat to determine the effect of vine killing on yield and processing quality over three harvest dates. The incidence of late blight on tubers in storage was measured to evaluate the effectiveness of diquat in reducing tuber infection during harvest. Compared to the untreated control, yield was reduced by desiccation with the largest reduction in total yield observed in the early September harvest; 23.7% in 1997, 16.8% in 1998. By the late September harvest, however, the effect of vine killing in reducing total yield was less apparent; 8.9% in 1997, 4.2% in 1998. Skin set was significantly higher in the desiccated treatment for all harvest dates in 1997 but only in the early September harvest in 1998. Glucose and sucrose concentrations were similar in tubers from the desiccated and untreated plots in both years of the study. Specific gravity was lower in the vine

killed treatment for all harvest dates in 1997 but only in the early and mid September harvests in 1998. The incidence of tuber rot in the early September harvest in 1998 was 5% lower in the desiccated treatment as compared to the control. Results from this study indicate that vine killing with diquat for a mid to late September harvest can be done in Manitoba with minimal effects on tuber yield and processing quality.

Salaiz, Thomas A. and Bradley M. Krohn. *Development of Low Black Spot Bruise Ranger Russet Via Antisense Inhibition of Polyphenol Oxidase.*

Polyphenol Oxidase (PPO) catalyzes the blackening reaction in potato tubers which are susceptible to black spot bruise. Three different binary gene constructs, designed to generate tuber-specific antisense inhibition of PPO, were independently transformed into Ranger Russet via *Agrobacterium*-mediated transformation. Transgenic lines ranging from intermediate reductions to complete elimination of PPO activity were identified by assay of greenhouse minitubers. The same low PPO lines were evaluated for reduction in black spot bruise susceptibility in 1998 field trials at Parma, ID, and Hancock, WI. In "bruise barrel" tumbling assays of mature field-grown tubers, samples were bruised and peeled, or bruised, stored at 8 C, and peeled. Several lines from two of the three gene constructs demonstrated virtually complete elimination of black spot bruises, both before cold storage, and after 4 months of cold storage. All three gene constructs produced lines with a range of intermediate levels of reduction in black spot bruises. All lines with a complete elimination of black spot bruises demonstrated a statistically-significant reduction in twenty-four hour abrasive peel ratings, in which peeled transgenic tubers remained nearly white. Currently, low bruise Ranger Russet lines which show preliminarily acceptable plant and tuber type-ness, have been advanced to 1999 agronomic field trials to select for commercial candidates.

Sanchez-López, Vladimir and Hector Lozoya-Saldaña. *Virus Incidence on International Potato Clones in The Toluca Valley, Mexico.*

In recent years, thousands of potato clones have been introduced to the Toluca Valley for evaluation of field resistance to potato late blight (*Phytophthora infestans*). This situation represents a potential risk of importing pathogenic agents with the planting material, in particular, viruses. In the International Cooperative Program for Potato Late Blight (PICTIPAPA) evaluation plots in Metepec, México, leaves

from 348 clones that have been in the valley for one to three years were sampled 75 days after planting in the 1998 growing cycle. After harvest, tubers from 227 selected clones from the same group were also taken to run ELISA on both leaves and tubers to detect the presence of seven viruses. From all the samples, 17% were positive for virus X (PVX); 1% for virus Y (PVY); 3% for virus S (PVS), and 1.4% for leaf roll (PLRV). Virus M (PVM), virus A (PVA), and Andean Latent (APLV) were not detected. A direct relationship was found between viral incidence and the number of growing cycles that the genotypes have been naturally exposed to the fungus in the field (20, 36, and 60% of the sampled clones evaluated for the first, second, and third year respectively were positive for at least one virus). We conclude that the plants acquired the viruses directly in the field.

Shock, Clinton C., Erik B.G. Feibert, Eric P. Eldredge, and Lamont D. Saunders. *The Response of Umatilla Russet to Nitrogen Fertilizer Rates And Irrigation Deficits.*

Umatilla Russet was compared with Russet Burbank, Shepody, and Ranger Russet for yield, grade, and processing quality response to four applied N rates under sprinkler irrigation in 1992, 1993, and 1994, and to four N rates under furrow irrigation in 1994, 1995, and 1996, and to four levels of sprinkler irrigation in 1992, 1993 and 1994. The varieties did not differ in average yield response to N rate, but specific gravity was reduced with increasing N rate. In the sprinkler irrigated N rate study, averaging over the three years at the optimum N rate each year, Shepody and Umatilla Russet had the highest yield of US #1 tubers. Russet Burbank and Umatilla Russet had the highest total yield. In the furrow irrigated N rate study Ranger Russet had the highest yield of US #1 tubers and large #1 tubers, followed by Umatilla Russet. Shepody and Umatilla Russet had the lightest stem end fry color. Deficit sprinkler irrigation decreased US #1 yield in all four varieties. Deficit irrigation did not reduce total yield of Russet Burbank, and severe irrigation deficit increased yield of US #2 tubers only in Russet Burbank. Specific gravity of Shepody was reduced by irrigation deficits, but remained stable in Russet Burbank and increased in Umatilla Russet. In the non-stressed check treatments, averaged over three years, Umatilla Russet had the highest total yield, the highest yield of US #1 tubers, and yield of large US #1 tubers as high as Shepody. In these trials, with optimum to adverse irrigation and N levels, Umatilla Russet demonstrated good stability in tuber yield, grade, and processing quality compared to the other varieties.

Sieczka, Maria T., Charles R. Brown, Edyta Gawrońska, Kazimierz M. Świeżyński, Hanna Zarzycka, and Ewa Zimnoch-Guzowska. *Identification of Potatoes Resistant to New Strains of Late Blight* (*Phytophthora infestans*).

Resistance to *Phytophthora infestans* has been evaluated in Polish and foreign cultivars reported to be resistant, and in diploid and tetraploid advanced selections obtained at Młochów (in the breeding program for *P. infestans* resistance). In addition, segregation for *P. infestans* resistance was evaluated in three diploid and three tetraploid seedling families originated from parents differing in resistance level.

In laboratory tests, two highly pathogenic strains of *P. infestans* were used: US 8 (A-2) and MP 322 (A-1), isolated in the U.S. and Poland, respectively. They exhibit similar pathogenicity to the evaluated potato genotypes. All material was parallelly evaluated under high natural infection pressure.

Among cultivars the highest level of foliar resistance was found in the Polish cv. Meduza and in the foreign cv. Cruza 148. Cv. Meduza was also resistant in tubers.

Preliminary data indicates that among diploid and tetraploid selections/seedlings some were superior to cvs in both foliage and tuber resistance. Among them genotypes have been found with satisfactory tuber quality and, quite significantly, maturity earlier than the most resistant cultivars: Meduza and Cruza 148.

Singh, U., C. Trevors, S. DeBoer, and J.D. Janse. *A Procedure For The Detection of Erwinia chrysanthemi in Potatoes*.

Erwinia chrysanthemi which is responsible for bacterial soft rot in potato is a quarantine organism for which specific and sensitive detection methods are required. In this study, both serological and DNA based techniques were used to develop detection systems for this bacterium. Monoclonal and polyclonal antisera were raised to this organism using glutaraldehyde treated cells as the antigen and a DAS-ELISA was developed. Using this ELISA, all potato strains of *E. chrysanthemi* originating from temperate regions of the world gave a strong positive reaction whereas non potato strains were not specific in their reaction. Heterologous bacteria were all negative in ELISA using the monoclonal antibody to *E. chrysanthemi*. Using published sequences, a PCR assay was developed for the detection of this bacteria. All strains of *E. chrysanthemi* regardless of origin gave a positive reaction whereas none of the heterologous bacteria were positive. A comparison of the two methods showed that the sensitivity of ELISA was 10^6 while that of the PCR was 10^3 cells per ml.

Sowokinos, Joe, Sanjay Gupta, and Irene Shea. *Purification and Characterization of Isozymes of UDP-Glc Pyrophosphorylase (UGPase) Unique to Potatoes Demonstrating Resistance to Cold-Induced Sweetening*.

Cold temperature (4 °C) accelerates starch breakdown in stored potato tubers and renders them unacceptable for the production of chips or fries. It is imperative that genes be identified which could confer resistance to cold-induced sweetening. The enzyme UGPase catalyzes the first step common to the sweetening pathway in potato tubers via the formation of UDP-Glc. Previous research has indicated that the polymorphism of UGPase seen at the allelic level bore a relationship to the polymorphism seen at the phenotypic level relating to a clone's ability to sweeten in the cold (Sowokinos *et al.*, 1997, Plant Physiol. 113:511-517). The major isozyme of UGPase (UGP3) found in the cold-sensitive (CS) cultivar Norchip has been previously purified and characterized (Sowokinos *et al.* 1993, Plant Physiol. 101:1073-1080).

In this study sixteen potato clones, differing in their ability to sweeten in the cold, were screened for isozymes of UGPase. Native-activity gels detected two new isozymes (UGP4 and UGP5) that were present only in cold-resistant (CR) potatoes. These isozymes were purified to near homogeneity from the CR cultivar Snowden. A subunit mass of 53 kD was found using denaturing gel electrophoresis. The deduced amino acid sequence yielded key differences between CS and CR polypeptides which led to proteins differing in charge. Differences in the kinetic properties between the isozymes from CS and CR clones will be discussed. This study is supported, in part, by USDA/Specific Cooperative Agreement # 58-5442-6-124.

Stein, Jeffery M., William W. Kirk, Robert L. Schafer, and Brendan A. Niemira. *The Role of Select Fungicides Within A Potato Late Blight* (*Phytophthora infestans*) *Control Program; Antisporulation And Tuber Blight Aspects*.

Late blight (*P. infestans*) control programs in which two of the standard chlorothalonil applications were replaced with novel fungicides or mixtures were examined under field conditions for foliar disease control, antisporulation capacity, and tuber loss reduction. The novel fungicide applications were targeted specifically at pathogen inoculation and/or crop desiccation events. All of the fungicide programs reduced foliar disease significantly in comparison to the untreated control, but not the season long chlorothalonil control. None of the fungicide programs significantly reduced

the number of sporangia produced per cm² lesion area. The late season dimethomorph/mancozeb program had significantly higher marketable tuber number per plant and yield than the untreated and chlorothalonil controls. The early season cymoxanil/mancozeb program had a significantly reduced level of season long tuber loss than both the untreated and chlorothalonil controls. Further relationships between fungicide programs, foliar disease levels, and tuber loss will be discussed.

Sterrett, S.B., M.R. Henninger, and K.G. Haynes. *Relationship of Internal Heat Necrosis to Specific Gravity*.

Most high specific gravity potato chipping cultivars grown in the mid-Atlantic states are susceptible to internal heat necrosis (IHN), a physiological disorder of the tuber parenchyma tissue. The purpose of this study was to investigate the relationship between susceptibility to IHN and specific gravity.

Twelve clones from 33 segregating tetraploid families were evaluated for both incidence and severity of IHN and specific gravity in replicated field plots in VA in 1994 and 1997. There was a highly significant correlation between incidence and severity of IHN in 1994 ($r=-0.90$, $P<0.01$) and 1997 ($r=-0.89$, $P<0.01$). The correlation between severity of IHN and specific gravity was low in 1994 ($r=0.07$, $P=0.05$) and in 1997 ($r=0.002$, $P=0.95$). Although the incidence and severity of IHN was greater in families with Atlantic as a parent, there was no correlation between incidence or severity of IHN and specific gravity in most of the families. This suggests that the increased susceptibility to IHN in segregating families with Atlantic as a parent is due to some factor other than high specific gravity.

Tek, Ahmet L., John P. Helgeson, and Jiming Jiang. *Molecular Cytogenetic Characterization of Solanum Brevidens Chromatin Introgressed into Potato*.

Eight BC₃ plants together with their parents derived from a single somatic hybrid between potato and *Solanum brevidens* were investigated using genomic *in situ* hybridization (GISH) and restriction fragment length polymorphism (RFLP) analysis. The somatic hybrid A206 had 24 *S. brevidens* chromosomes and 48 potato chromosomes as expected. One of the two BC₁ parents contained 11 *S. brevidens* chromosomes and the other BC₁ parent had 11 complete *S. brevidens* chromosomes and a potato-*S. brevidens* translocation chromosome. Two BC₂ parents analyzed had three and four complete *S. brevidens* chromosomes,

respectively. Among the eight BC₃ progeny, two possessed a translocation chromosome, five contained a single complete *S. brevidens* chromosome and one plant had one translocation chromosome and one complete *S. brevidens* chromosome. We demonstrated that it should be possible to isolate a complete set of 12 addition or substitution lines. The potato-*S. brevidens* translocation chromosomes probably originated from genetic recombination. This recombination potential between potato and *S. brevidens* chromosomes provides the basis for introgression of useful genes from *S. brevidens* into potato.

Thill, Christian A., E.B. Radcliffe, and D.W. Ragsdale. *Breeding For Potato Leafhopper Resistance Using Wild Solanum Species*.

Potato cultivars and germplasm developed with resistant to potato leafhopper (PLH) are important; substantial yield losses result when PLH is not controlled. Moreover, chemical control of PLH causes green peach aphid (GPA) outbreaks and GPA spread potato virus Y (PVY) and potato leafroll virus (PLRV). Resistance to PLH is found among the wild relatives of potato. In previous work, we evaluated 120 accessions from 32 *Solanum* species and found resistance to segregate between species and significantly among species' accessions. Subsequently, twelve species from 31 accessions were evaluated to identify individual genotypes (fine screening) within accessions conferring resistance. Resistance was assessed by counting the number of PLH adults and nymphs following vacuum-suction sampling of individual genotypes. Three species, *S. berthaultii* (P.I. 208881, 320257, 473331, 498105), *S. megistacrolobum* (310936), and *S. polytrichon* (184770) had the best resistance against both PLH nymphs and adults. All genotypes within accessions of these species had greater than 5x the resistance of susceptible cultivars Russet Burbank and 15x that of Cascade. Our future objectives are to transfer PLH resistance to cultivated potatoes using *S. tuberosum* haploids and 2n gametes and determine the basis of PLH resistance.

Thill, Christian A., E.B. Radcliffe, D.W. Ragsdale, R.E. Haneman, Jr., and J.B. Bamberg. *The Identification of Aphid Resistant 4X Potato Germplasm For Use in Breeding*.

PLRV reduces market tuber yield by diminishing internal tuber quality through expression of net necrosis. PVY reduces plant productivity and yield. Spread of PLRV by aphids that colonize potatoes is persistent, while PVY spread is non-persistent during aphid probing while feeding. High aphid

populations in Minnesota since 1995 and yield losses of 35% in 1998 have been reported. We evaluated 100 4x parental clones (complex interspecific hybrids) and 348 new progeny (4x-complex interspecific clones crossed to cultivars) for resistance to aphids. Resistance segregated in the 4x population and ranged from 77 to 7600 aphids per plot (5 compound leaves from each of 4 plants). Twenty-one 4x clones had better aphid resistance than Russet Burbank (740). These will be used in crosses to develop new hybrid progenies. Existing new hybrid progenies had aphids ranging from 4-1700 per plant and 39% had better resistance than Russet Burbank. The best families were Atlantic x MN85345 (92% of the progeny were aphid-resistant), Snowden x MN85348 (45%), W1005 x MN85348 (50%), MN85348 x Ranger Russet (80%), and MN85477 x Ranger Russet (67%). Progenies are being evaluated for resistance to PLRV and PVY using ELISA. The best clones will be increased and evaluated for horticultural and processing characteristics.

Varrieur, John M., Rebecca J. Cutright, and Richard E. Veilleux. *Selection Pressures Inherent in The Monoploid Derivation-Mechanisms, Androgenesis And Gynogenesis.*

Monoploid potato is free of deleterious alleles and can be used to develop homozygous lines through chromosome doubling. Three studies were conducted to analyze monoploid populations derived from *Solanum phureja* clones PP5 and 1-3 to observe selection inherent in either androgenesis or gynogenesis. *S. phureja* PP5 clones from both derivations were planted from tubers in 10 cm pots in April 1998 and transplanted to the field in May 1998 in a completely randomized design of 1-plant plots with 21 clones in 3 replications. Mean squares due to derivation for 7 traits were evaluated using the mean squares for genotypes within derivation as error. Significant differences between derivations were found for shoot and tuber number with androgenic exceeding gynogenic for both (3.3 vs. 2.0 shoots and 6.7 vs. 1.8 tubers per plant, respectively). Androgenic and gynogenic monoploids (74 total) from both parental lines were planted from cuttings in 10 cm pots in Dec. 1998 in a randomized complete block of 1-plant plots in 3 replications in the greenhouse under 16 h day length. Preliminary results indicated no significant differences between derivations for 3 traits: vigor, height and stem number. Flow cytometry of 9 androgenic and 10 gynogenic plantlets derived from 1-3 revealed no significant difference for DNA content per nucleus between derivations.

Wahab, Jazeem, Doug Waterer, and Terry Hogg. *Optimizing Fertility Levels And Plant Populations For Potato Grown Under Short Growing Seasons.*

Cultivar specific agronomic practices suited for Saskatchewan's short, cool growing season are being developed for "seed" and "consumption" (processing and fresh market) grade potato. This study examined factorial combinations of nitrogen and phosphorus and seed piece spacing for Russet Norkotah (mid-season, fresh market), Shepody (mid-season french fry), and Ranger Russet (very-late, french fry) potato. Fertility levels were 50 - 200 kg N/ha and 60 - 120 kg P₂O₅/ha with 15 or 30 cm in-row seed spacing.

Ranger Russet produced lower "seed" and "consumption" grade tuber yields than Russet Norkotah or Shepody. Yield responses to nitrogen and phosphorus levels were similar for the two market classes and interactions between the test factors were limited. Optimum yields for Russet Norkotah and Ranger Russet were obtained with 150 kg N/ha. Shepody yields increased through to the highest nitrogen level tested (200 kg N/ha). Applying 120 kg P₂O₅/ha produced little advantage over 60 kg P₂O₅/ha. The 15 cm seed piece spacing significantly outyielded the 30 cm spacing, irrespective of the fertility level. Fertility and seed piece spacing effects on yield components, tuber specific gravity, and related economic implications are discussed.

Walters-Felcher, Kimberly, Wenbin Li, and Dave Douches. *Molecular Characterization And Disease Reaction of Transgenic Potato Plants Carrying A Fungal Glucose Oxidase Gene.*

Late blight, (*Phytophthora infestans*), is one of the most devastating diseases of potato worldwide and the development of cultivars resistant to this disease is an important objective for many potato breeders. Current emphasis is on utilization of horizontal resistance rather than vertical resistance conferred by specific R genes. Our research was undertaken to determine if enhanced resistance to late blight could be obtained by combining natural resistance and engineered resistance conferred by the fungal transgene glucose oxidase. This gene was selected due to its reported effect against multiple pathogens including *P. infestans*, *Erwinia carotovora*, *Alternaria solani*, and *Fusarium sambucinum*. Late blight susceptible cultivars Atlantic, Snowden and Spunta and partially resistant cultivars Zarevo and Libertas were transformed with the glucose oxidase gene under the control of the Gelvin Super Promoter. Putative transgenic lines were

verified and copy number determined via Southern blotting. Copy number ranged from 1 to 7. Lines containing the glucose oxidase transgene were evaluated for reaction to *P. infestans* in growth chambers and/or inoculated field studies. Results from both types of studies revealed no significant effect of the transgene in either susceptible or partially resistant cultivars. Lines for which tubers were available were tested for reaction to *Erwinia carotovora* (soft rot) and *Fusarium sambucinum* (dry rot). All transgenic lines tested were significantly better than non-transgenic controls for lesion diameter and depth when inoculated with *E. carotovora*. Four transgenic lines (SGO-1, SGO-2, SGO-14, and SGO-26) and two transgenic lines (SGO-3, and SGO-26) were significantly better than the non-transgenic control for lesion diameter and depth respectively when inoculated with *F. sambucinum*. Our results indicate that glucose oxidase will not be an effective component of a combined resistance strategy to develop late blight resistance in potatoes but may be useful in a similar strategy for developing soft rot resistance.

Weingartner, D.P. and K.G. Haynes. *Inheritance of Resistance to Corky Ringspot*.

Corky ringspot (CRS) in potato tubers is caused by tobacco rattle virus which in Florida is transmitted by trichodoriid nematodes, principally *Paratrichodorus minor*. External tuber symptoms range from prominent concentric rings of alternating living and necrotic tissue to small necrotic flecks. The internal tuber symptom is necrosis. Twenty crosses between CRS susceptible and resistant parents were made using a design II mating scheme. Twenty-five progeny from each cross were planted in 1997 in a randomized complete block design with three replications in a trichodoriid infested field in Hastings, FL. Incidence and severity of CRS were recorded at harvest. Approximately 14% of the tubers showed internal symptoms but only 4% of the tubers showed external symptoms of CRS. Additive variance was approximately twice as great as dominance variance for both incidence and severity of CRS. Because the inheritance of resistance to CRS is controlled by no more than one or two genes breeding for resistance should be a relatively direct process.

Wright, Ryan. *The Profitability of Growing Soybeans in Rotation With Potatoes in Maine*.

This research examines the profitability of growing soy-

beans as a crop in rotation with potatoes in Maine, and how this crop affects the profit level of the entire farm operation. One goal of the Maine Potato industry is finding more profitable crop rotations. However, maximizing the profit of a farm cannot look only at the primary crop produced (potatoes); it must examine the profitability of the entire cropping system.

Enterprise budgets are constructed separating the costs of soybean production on a per acre basis for a hypothetical farm. The budgets include any rotational benefits soybeans offer potato production. Information from the American Society of Agricultural Engineers 1997 Standards, local data, and budgets from other states are used to calculate variable costs of production. The Agricultural Research Service office in Orono, Maine conducted field trials in Newport and Presque Isle, Maine. Data gathered from these trials are used to examine the rotational effects of including soybeans in a potato rotation. Sensitivity analysis is conducted on the estimated revenues and variable costs of production determining a range of profitable production conditions.

Yencho, G.C., S.P. Kowalski, G.G. Kennedy, and L.L. Sanford. *Leptine Glycoalkaloids And Colorado Potato Beetle Resistance in F2 Solanum tuberosum x S. Chacoense Progenies*.

S. chacoense (*chc*) is resistant to the Colorado potato beetle. Resistance has been associated with the presence of leptine glycoalkaloids. Seven tetraploid, F2 *S. tuberosum* x *S. chacoense* families of 33 sibs each were evaluated for production of leptines I and II, leptinines I and II, and α -solanine and α -chaconine, and screened for resistance to CPB in laboratory and field defoliation experiments. Resistance was correlated with the concentrations of foliar glycoalkaloids on a family and individual basis. Leptine concentrations ranged from undetectable to a high of 18.0 mg/g DW. All of the progeny produced solanine and chaconine. Family 9623, which had the highest mean leptine concentration had the lowest mean leaf disk feeding and CPB defoliation levels. Family 9616, ranked as the lowest glycoalkaloid producer, ranked as one of the most susceptible families. Regression analyses of the traits solanine + chaconine, leptine I and II, and leptinine I and II foliar concentrations versus leaf disk consumption and field defoliation revealed that only increased foliar levels of leptines resulted in decreased CPB feeding. The linear regression models for leptines versus leaf disk consumption and field defoliation were highly significant ($p < 0.0001$) accounting for 17% and 26% of the variation

in consumption and defoliation, respectively. Results are discussed within the context of breeding for resistance to CPB.

Zlesak, David C. and C.A. Thill. *The Identification of Late Blight Resistance in 1, 2, And 4EBN Wild Solanum Species For Use in Breeding.*

Resistance to *Phytophthora infestans* (US8, A2) was evaluated in 1928 seedling genotypes from 51 accessions across 13 *Solanum* species. Species evaluated were 2x IEBN *S. bulbocastanum*, *S. cardiophyllum*, *S. commersonii*, *S. pinnatisectum*, and *S. trifidum*; 2x 2EBN *S. berthaultii*, *S. microdontum*, *S. stoloniferum*, and *S. verrucosum*; 4x 2EBN *S. fendleri*; 6x 4EBN *S. guerreroense*; and 2x ? EBN *S. megistacrololbium* and *S. polyadenium*. Infection proceeded after placing seedlings (2 replications of 24 seedlings per accession) between inoculated rows of cv. Norchip and by direct spray inoculation 12 days after placement. Resistance was determined using the CIP scale (1=0% to 9=100% infection) then converted to AUDPC scores. Resistance was found to segregate between species and AUDPC ranged from 555 (*S. cph*) to 1932 (*S. mga*). The most resistant species were *S. cph* (555), *S. blb* (649), *S. pld* (1075), and *S. pnt* (1178). *S. blb* and *S. cph* had the greatest variability among accessions, while *S. pld* and *S. pnt* had the least. Moreover, resistance segregated within accessions i.e. *S. blb*: P.I. 243512 (35-1075), P.I. 243345 (315-1312), and P.I. 342505 (110-1072). The most resistant accession was *S. blb* 243512; 36 of 48 genotypes had no more than 25% plant defoliation. Ninety-five resistant seedlings were selected 56 (IEBN), 27 (2EBN),

and 12 (? EBN) for use in breeding. Selected seedlings (2EBN) will be crossed to haploid-species hybrids and cultivars; (IEBN) will be somatically doubled prior to crossing to haploid-species hybrids.

Zvomuya, Francis, Carl Rosen, and Mike Thornton. *Response of Superior And Newleaf Superior Potato Clones to Nitrogen.*

During genetic transformation of potatoes, single plants are selected from tissue culture and then clonally propagated. Backcrossing to the standard clone is not performed due to the heterozygous nature of potatoes. Therefore, in addition to the genetic transformation for the selected trait, chances of obtaining differences in other traits are high. NewLeaf Superior potato has been shown in previous field trials to be more vigorous than the standard clone. The objective of this study was to determine the effect of nitrogen fertilizer on yield and quality of standard and Newleaf Superior potato clones. A two year field study was conducted at the Sand Plain Research Farm in Becker, Minn. on a Hubbard loamy sand. Four N rates were tested: 25, 100, 200, and 300 lb N/A in a split plot design replicated four times. Significant N rate by genotype interactions for total tuber yield were obtained each year. Yield was optimized at 100-200 lb N/A for the NewLeaf clone in contrast to 200-300 lb N/A for the standard clone. Nitrogen rates higher than 200 lb N/A depressed yield of the NewLeaf clone. Differences in N response were likely due to increased vine growth and a delay in maturity of the NewLeaf clone compared to the standard type.